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SWINE RESEARCH PROGRESS REPORT

Part I-e of

Animal-Poultry and Products Research

A summary of current program and preliminary report of progress of the United States Department of Agriculture and related work of the State Agricultural Experiment Stations.

This progress report is primarily a research tool for use of scientists and administrators in program coordination, development, and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of research progress include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members, and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S.D.A. and cooperative research issued during the past year. Current agricultural research findings are also published in the monthly U.S.D.A. publications, Agricultural Research and The Farm Index.

UNITED STATES DEPARTMENT OF AGRICULTURE
Washington, D. C. 20250

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The research program pertaining to swine is reported in two volumes: Part I-e and Part II of Animal-Poultry and Products Research. This volume contains a report of farm research that applies to swine production. The companion volume, Part II, contains additional information applicable to swine along with information pertaining to other classes of livestock.

The following subject matter progress reports are prepared by U.S.D.A. The number prefixes refer to advisory committees listed later that review the research reported:

- 6 - Forestry (other than Forest Service)
- 7 - Beef Cattle, Part I-a
- 7 - Dairy, Part I-b
- 7 - Poultry, Part I-c
- 7 - Sheep and Wool, Part I-d
- 7 - Swine, Part I-e
- 7 - Animal-Poultry and Products, Part II
- 8 - Cotton and Cottonseed
- 9 - Grain and Forage Crops
- 10 - Horticultural Crops
- 11 - Oilseed and Peanut
- 11 - Sugar
- 13 - Tobacco

The information contained in the above subject matter reports was first reported in the following organizational unit reports. As above, the number prefixes refer to advisory committees listed later that review all of the work of the respective divisions or services.

Agricultural Research Service (ARS)

- 1 - Agricultural Engineering
- 1 - Soil and Water Conservation
- 2 - Utilization -- Eastern
- 2 - Utilization -- Northern
- 2 - Utilization -- Southern
- 2 - Utilization -- Western
- 3 - Human Nutrition
- 3 - Clothing and Housing
- 3 - Consumer and Food Economics
- 4 - Market Quality
- 4 - Transportation and Facilities
- 7 - Animal Husbandry
- 7 - Animal Disease and Parasite
- 12 - Crops
- 12 - Entomology

Economic Research Service (ERS)

- 1, 5 - Economic Development
- 4, 5 - Marketing Economics
- 5 - Farm Production Economics
- 5 - Economic and Statistical Analysis
- 5 - Foreign Development and Trade
- 5 - Foreign Regional Analysis
- 5 - Natural Resource Economics
- 6 - Forest Service - Research (FS)
- 4, 5 - Farmer Cooperative Service (FCS)
- 4, 5 - Statistical Reporting Service (SRS)

The research program of the Department of Agriculture is reviewed annually by the following advisory committees:

1. Farm Resources and Facilities Research
2. Utilization Research and Development
3. Human Nutrition and Consumer Use Research
4. Marketing Research
5. Agricultural Economics Research
6. Forestry Research
7. Animal and Animal Products Research
8. Cotton Research
9. Grain and Forage Crops Research
10. Horticultural Crops Research
11. Oilseed, Peanut and Sugar Crops Research
12. Plant Science and Entomology Research
13. Tobacco Research

A copy of any of the reports may be requested from Max Hinds, Executive Secretary, Animal and Animal Products Research Advisory Committee, Research Program Development and Evaluation Staff, U. S. Department of Agriculture, Washington, D. C. 20250

INTRODUCTION

The swine research program reported in Part I-e and Part II, Animal-Poultry and Products Research Progress Reports, covers work directly related to the production, processing, distribution, and consumption of pork. The information has been assembled from the organizational unit reports of the several divisions. This report does not include extensive cross commodity work, much of which is basic in character, which contributes to the solution of not only swine problems but also to the problems of other commodities. Progress on cross commodity work is found in the organizational unit reports of the several divisions.

These reports are organized by "Problem Areas" which are shown in the table of contents. For each area there is a statement of (1) the problem, (2) the USDA program, (3) State experiment station programs, (4) a summary of progress during the past year on USDA, and cooperative work, and (5) a list of publications resulting from USDA and cooperative work.

Research on animal-poultry and products problems is supported by (1) Federal funds appropriated to the research agencies of the USDA, (2) Federal and State funds appropriated to the State agricultural experiment stations, and (3) private funds for research carried on in private laboratories or for support of State station and USDA work.

Research by USDA

Farm research pertaining to swine is conducted in the Agricultural Research Service divisions of Agricultural Engineering, Animal Disease and Parasite, Animal Husbandry, and Entomology. The work comprises investigations of breeding, physiology, nutrition, diseases and parasites, housing equipment, management and production influences on animal products. The work involves an estimated 56 professional man-years of scientific effort.

Nutrition, consumer, and utilization research pertaining to pork is conducted in the Agricultural Research Service divisions of Human Nutrition, Consumer and Food Economics, and Eastern Utilization. The work comprises investigations of composition and nutritive value; physiological availability of nutrients and their effects; new and improved methods of preparation, preservation, and care in homes, eating establishments and institutions; and with the processing phase involving slaughter, cutting, trimming, smoking, curing, and preparing for later use by consumers. The work includes considerable emphasis on chemical and physical properties of meat. Also, it is concerned with improved equipment and processes. The work in these divisions involves an estimated 22 professional man-years of scientific effort.

Marketing and economic research pertaining to live animals and pork is carried on within four Services: Agricultural Research Service, Economic Research Service, Farmer Cooperative Service, and Statistical Reporting Service. The work comprises (1) physical and biological aspects of assembly, packaging, transporting, storing and distribution; (2) economic aspects of marketing costs, margins and efficiency, market potential, supply and demand, and situation and outlook; (3) cooperative marketing, and (4) consumer acceptance studies. The divisions in which the work is conducted are: Market Quality, ARS; Transportation and Facilities, ARS; Marketing Economics, ERS; Economic and Statistical Analysis, ERS; Marketing Division, FCS; Standards and Research, SRS. The scientific effort involved by these divisions is estimated at 10 professional man-years.

Interrelationships among Department, State and Private Research

A large part of the Department's research is cooperative with State Experiment Stations. Many Department employees are located at State Stations and use laboratory and office space close to or furnished by the Station. Cooperative work is jointly planned, frequently with the participation of representatives of the producers or industry affected. The nature of cooperation varies with each study. It is developed so as to fully utilize the personnel and other resources of the cooperators which frequently includes resources contributed by the interested producers or industry.

Including both cooperative and State Station projects swine research is carried in 47 of the 53 State Experiment Stations. The types of work to which the largest amount of effort is devoted include breeding, physiology, nutrition and management, diseases and parasites, marketing and economics, and utilization research on meats and animal fats. There is regular exchange of information between Station and Department scientists to assure that the programs complement each other and to eliminate unnecessary duplication.

Privately supported swine research emphasizes the solution of scientific production, processing, and marketing problems. Much of it utilizes the results of basic work done by State Station and Department scientists.

About one-third of industry's contribution to the research effort pertains to farm research. Industry does most of its own poultry breeding research but very little beef breeding research, except the work of large firms like the King Ranch which developed the Santa Gertrudis breed. In the case of swine there is a real opportunity for increased participation by industry. The task of evaluating breeds, the performance of breeds in crossing, and the comparison of crossing systems will take more animals than are available at publicly supported experiment stations.

About equal to the farm research effort in the livestock industry, another one-third is in the utilization field. In contrast with the public research in basic work the industry program places strong emphasis on developmental activities and solving of immediate problems. The work of meatpackers is devoted to finding industrial utilization of by-products, quality control devices, improved formulation of products, improved handling and plant arrangement. Independent laboratories and foundations take on short time problem-solving for clients in the meat industry. Pharmaceutical firms carry on research on extraction of biologically active substances from meat by-products such as hormones from glands, and with the development of agents, such as antibiotics for use in meat processing.

The contributions of swine producers and industry to the work of the State Stations and the Department have been an important factor in the success of their research programs. Producers offer herds and facilities for testing products and practices used in production. Likewise, processors and re-tailers offer facilities and products for use by public research agencies. Many problems in the economics of marketing cannot be transferred to a laboratory, experimental plot, or other simulated situation. The results of economic research conducted cooperatively is of great value to industry, especially in cases where public research can provide comparison and analysis. Even large firms that have a research staff do not have access to the plants and records of competitors.

Examples of Recent Research Accomplishments by USDA and Cooperating Scientists

Control of estrus in swine. A synthetic drug mixed with feed resulted in groups of gilts coming in estrus and being bred over a three-day period. No adverse effects were observed and normal litters were farrowed at the end of normal gestation periods. This research offers for the first time the possibility for (1) extensive use of artificial insemination in swine, (2) more efficient use of facilities and labor by scheduling the date for groups of sows, (3) breaking disease cycles in baby pigs by avoiding overlap in farrowings, (4) producing market hogs in uniform groups, and (5) more effective research by controlling the birth date of experimental animals.

Ventilation of livestock buildings. Research in cooperation with State experiment stations has obtained much needed basic data on the heat and moisture given off by cattle, hogs, and poultry, and on the influence of building environment on production and feed consumption. The heat and moisture dissipation data are considered basic design data for ventilation systems of poultry, dairy, and swine buildings. They appear in design handbooks including the 1965 Guide and Data Book of the American Society of Heating, Refrigeration, Ventilating, and Air Conditioning Engineers, and are used by makers of ventilating equipment, prefabricated buildings and package buildings as well as by specialists advising farmers on their own construction. Building improvements resulting from the above research have contributed to the substantial rise in efficiency of livestock production that has occurred during the past decade.

The pathogenesis of brucellosis in male swine studied. Sexually mature boars were exposed to Brucella suis and were killed at intervals after exposure to determine the pathogenesis of brucellosis in boars. Clinical signs were observed, serologic and bacteriologic studies of blood samples were conducted, and tissues were thoroughly examined at necropsy for pathologic and bacteriologic evidence of infection. The period in which isolations of Br. suis were most frequently made and histopathologic alterations most often observed extended from 2 through 6 weeks post-exposure. Brucella suis was isolated most frequently from lymph nodes and accessory genital glands. Gross pathologic alterations were confined to seminal vesicles and their regional lymph nodes. Histopathologic alterations were observed most frequently in lymph nodes, accessory genital glands, livers, and bones.

Carrier swine chronically affected by leptospirosis cured with antibiotics. Leptospire were eradicated from the kidneys of carrier swine by injections of streptomycin. The method will be of value in the control of leptospirosis in domestic animals. Although the treatment requires subcutaneous injections at the present time, investigators at the National Animal Disease Laboratory are searching for drugs which can be administered in the feed or drinking water.

Two viruses may be associated with transmissible gastroenteritis of pigs. Continuing research on transmissible gastroenteritis (TGE) of swine has indicated that there are two viruses which may be associated with TGE. One virus, a cytopathic virus, has been isolated from the intestinal tissue from several outbreaks of TGE. Antibodies against this virus are present in some of the convalescent sera from outbreaks of TGE in the field. Characterization studies indicate that the cytopathic virus belongs in the myxo class of viruses. The noncytopathic virus has been isolated from one outbreak of TGE from which the cytopathic virus could not be isolated, and from one outbreak of TGE from which the cytopathic virus had already been isolated. There is no apparent cross protection nor cross neutralization between the two viruses. Either virus can produce vomiting and diarrhea in newborn pigs. The role and relationship that each of these two viruses play in the overall disease, the problem of laboratory diagnosis, and the control and treatment of TGE will be elucidated by further research.

Destruction of trichinae by freezing at 0°F. delayed by previous exposure to near-freezing temperatures. Research at the Beltsville Parasitological Laboratory on the effects of cold temperatures on trichinae indicate that prolonged exposure to 34°F. increases the capacity of trichinae in fresh pork to resist destruction by freezing. One-pound patties of fresh ground pork, containing 25,000 to 270,000 trichinae per pound, were precooled to 34°F. for 51 and 135 days, respectively, immediately before being exposed to 0°F. in a home freezer of 9 cubic feet capacity. Trichinae in pork precooled to this temperature for the periods indicated survived exposure to 0°F. for 89 to 144 hours, respectively, whereas, trichinae in patties not so treated lived only 72 hours. These results show that the temperatures at which trichinous pork is held prior to freezing may influence the time required to kill them by this method.

Color Formation in Cured Pork Products Studied. A uniform pink color in cured pork and hams is considered an important quality characteristic in modern meat marketing practices. Research conducted under a P.L.-480 grant in Great Britain is leading to a better understanding of the factors responsible for color irregularities in cured pork products. The research results are assisting to clarify the special roles of cellular constituents and enzyme systems in color production. In the more direct or technological approach, studies with muscle minces are revealing the effect of processing variables upon color formation. One of these findings applicable to commercial curing practices shows that although the initial rate of pigment conversion is slower at lower temperatures, the rate on prolonged incubation may be higher. Continued research along these lines is expected to define the optimum curing environment and to specify those meat enzymes essential to the development of good color in pork products.

Electrically Operated Gates Can Reduce Livestock Marketing Costs. Electrically operated gates that speed up handling of livestock through the sales ring and reduce labor requirements for the selling operation are being tested at a livestock auction market in Mexico, Mo. The auctioneer controls the movement of livestock into and out of the sales ring by pushbutton control of the gates, thus eliminating the need for workers in the ring to open and close the gates. Central control by the auctioneer of entrance, selling, and exit also eliminates some of the delays and mixups that occur under conventional handling methods.

I. FARM RESEARCH

SWINE - BREEDING

Animal Husbandry Research Division, ARS

Problem. Improvements in the heredity of swine depend on the intensity and accuracy of selection practiced in choosing breeding animals and on the choice of a mating system that maximizes the rate of genetic improvement. Crossbreeding swine for the production of market animals has so proved its value that over 90% of the pigs marketed in the United States are currently some kind of crossbreds. Research in swine breeding thus is faced with the dual challenge of developing foundation seed stock populations that yield maximum improvement for commercial production and also devising methods that fully utilize the genetic potential of available seed stocks for further increases from heterosis and hybrid vigor generally shown by crossbred pigs. It is essential that experimental work continue the development of genetic facts and practical methods that breeders can use to develop better and more efficient seed stock strains. Particular effort is needed on effective genetic means for efficient production of pork with more lean and less fat without sacrificing gains in other production traits.

USDA AND COOPERATIVE PROGRAM

This is a continuing program of basic and applied research conducted by geneticists and animal husbandmen to elucidate genetic principles and develop effective breeding systems that will result in further increases in the efficiency of swine with respect to productivity and carcass value. This is a coordinated research effort involving the USDA and several State agricultural experiment stations. Research is in progress at Beltsville, Maryland, cooperatively with the Montana Agricultural Experiment Station at Miles City, Montana, and at the Regional Swine Breeding Laboratory with headquarters at Ames, Iowa. The Regional Laboratory includes cooperative projects at State Agricultural Experiment Stations in Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Nebraska, North Carolina, Oklahoma, South Dakota, and Wisconsin. Investigations on genetic principles, selection, and breeding systems include work with swine and also with laboratory animals on important performance traits, their heritabilities, and their phenotypic and genetic correlations. The results of such studies provide the basis for emphasis given to different complex traits and the underlying factors in evaluating different systems for achieving genetic changes. Traits of major interest include productivity of dam, viability, growth rate, feed efficiency, carcass composition, and quality of meat.

Cooperative research with the Food and Drug Administration is in progress to investigate the response of "miniature" swine to further reduction in body size from selection, and their usefulness for toxological tests as well as basic studies in nutrition and genetics.

A grant with the College of Agriculture, Poznan, Poland, provides for investigations on red blood cell and serum antigens to establish the mode of

inheritance and relative frequencies of these antigens in certain breeds of swine. Its duration is for five years, 1962-1966, and involves PL-480 funds.

The Federal scientific effort in this area totals 7.4 professional man-years. Of this number, 5.2 are devoted to genetics and interrelations of performance traits and 2.2 to selection and breeding systems.

PROGRAM OF STATE EXPERIMENT STATIONS

Swine breeding research uses experiment station animals, herds of cooperating swine producers, and litters on tests in swine testing stations. Economic traits being considered include growth rate, feed deficiency, maternal ability, litter size, viability, and carcass yield and quality. Areas of investigation include estimation of genetic parameters, comparison of methods of selection and breeding systems, and evaluation of crossbreeding. In some instances, interrelationships of genetics and certain environmental factors such as housing, nutrition, and management are also being studied. Genetic parameters of interest include heritability (the degree which traits are influenced by genetic factors) of the above economic traits and the genetic and environmental relationships between these traits.

Much of the research on evaluation of breeding systems concerns the effectiveness of mass selection based on one or more of the economic traits. In addition, evaluation of recurrent selection to increase combining ability is being conducted. Meatiness of the carcass is one of the most important economic traits. Selection programs have recently been initiated to select for decreased backfat at market age. Crossbreeding in swine has been widely adopted by the industry. Research is in progress to determine the relative degrees of hybrid vigor resulting from crosses between specific breeds and strains and the value of selection within strains for the ability to combine well in crosses. Various systems of crossbreeding including crisscrossing, three-way crosses, and multiple breed crosses are being evaluated. Efforts are also under way to develop new breeds from crossbred foundations, and attempts are being made to maintain the superiority of crossbreds for every trait.

The North Central stations, in addition to North Carolina and Oklahoma, conduct swine breeding research in cooperation with the USDA through the Regional Swine Breeding Laboratory with headquarters at Ames, Iowa.

The total research effort on swine breeding research by the State agricultural experiment stations is 20.5 professional man-years.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

A. Genetics and Interrelations of Performance Traits

Skeletal data obtained on selected and control line Duroc and Yorkshire pigs

showed similar trends with respect to breed and line differences as those reported last year. The number of thoracic and lumbar vertebrae averaged 20.5, 20.8, and 20.8 for tenth generation high-fat, low-fat, and control line Duroc pigs and 21.0, 21.2, and 21.8 for eighth generation high-fat, low-fat, and control line Yorkshire pigs. The corresponding averages for number of ribs were 14.4, 15.0, and 14.9 in the Duroc lines and 15.2, 15.2, and 15.5 in the Yorkshire lines. A total of 63 pigs were available for study with a range of from 6 to 12 pigs among lines. (AH al-12)

A study of sexual maturity with gilts being raised for breeding in a reciprocal recurrent selection program is now in its third year. The 137 gilts available for study this year were from the same four breed groups as those used during the first year. The two sets of crossbred gilts, designated by the symbols S-LB and S-BL, averaged about 10 pounds heavier and about 22 days younger in age at first estrus than the two sets of straightbred control gilts, C-LL and C-BB. Age at first estrus averaged 198, 202, 217, and 229 days for LB, BL, C-BB, and C-LL gilts, respectively. These results point in the same direction as those obtained for the same four groups in 1962 and, when considered with results obtained in 1963, confirm the conclusion that the selection practiced in the select strains S-LL and S-BB has had the effect of reducing age at first heat in both crossbred and straightbred gilts out of select strain females. (AH al-13)

Data collected over a three-year period on 477 gilts from Duroc and Yorkshire lines being selected on the basis of backfat thickness showed high-fat, low-fat, and control line Duroc gilts averaging 202, 201, and 195 days in age at first estrus, while high-fat, low-fat, and control line Yorkshire gilts averaged 211, 192, and 195 days, respectively. Over the same three years, about 3, 14, and 2% of the high-fat, low-fat, and control line Duroc gilts available for study failed to come in heat, compared with 19, 7, and 5% for high-fat, low-fat, and control line Yorkshire gilts. (AH al-12)

Data from 301 sows and 390 gilts showed statistically significant correlations of $-.16$, $-.12$, and $.12$ between gestation length and litter size at birth, litter weight at birth, and pig weight at birth. Positive phenotypic correlations of $.12$, $.19$, and $.16$ were obtained for age of gilt at breeding with litter size, litter weight, and average pig weight. The association of age of gilt with litter size and litter weight was found to be primarily a result of older gilts being heavier at breeding. Gestation gain in weight of gilt showed correlations of $-.14$ with litter size and $.16$ with average pig weight. The correlations of litter size with litter weight and individual pig weight were $.83$ and $-.55$, respectively. (AH al-8)

A study of 185 individually fed straightbred and crossbred Duroc and Yorkshire pigs showed phenotypic correlations of $.76$ between daily gain and daily feed consumption, $.24$ between daily gain and feed efficiency, and $-.54$ between daily feed consumption and feed efficiency. Estimates of the corresponding genetic correlations were $.90 \pm .07$, $.63 \pm .26$, and $.20 \pm .47$. The phenotypic and genetic correlations of percent lean cuts and carcass backfat with daily gain,

daily feed consumption, and feed efficiency suggested that selection for rate of gain would improve feed efficiency but would also be expected to increase backfat. Thus, both gain and backfat would have to be considered if improvement in these characters and in feed efficiency were desired. (AH al-10)

Backfat measurements taken at 125, 150, and 175 pounds on 208 boars and 233 gilts of a mildly inbred line of Poland China swine averaged .68, .76, and .87 inches for boars and .68, .78, and .88 for gilts. Phenotypic correlations between backfat probes at different weights ranged from .53 to .68 for boars and from .54 to .65 for gilts. Genetic correlations between probes at the same three weights ranged from .69 to .96, while the corresponding environmental correlations ranged from .16 to .43. Heritability estimates for backfat thickness were $.62 \pm .21$, $.42 \pm .17$, and $.35 \pm .16$ at 125, 150, and 175 pounds, respectively. (AH al-21)

A prediction equation was developed from data on 229 pigs for estimating pounds of lean cuts (Y) from line weight (W) and backfat probe (P). The equation $\hat{Y} = 12.9002 + .374 W - 10.30 P$ differs only slightly from one developed last year, and application of last year's equation to this year's data gave reasonably accurate predictions. (AH al-20)

One hundred and fourteen barrow-gilt littermate pairs from three lines of breeding were evaluated for differences in performance and carcass merit. Barrows gained .19 pound per day more and reached 200 pounds 12 days earlier. Gilt carcasses were .6 inch longer and had .10 inch less backfat, .44 square inch larger loin-eye area, and 4.1% higher yield of lean cuts. Feed efficiency records were essentially the same for both sexes. Differences between lines, sire groups, and sexes were significant for both marbling and firmness. Loins from barrows were firmer and had more marbling than loins from gilts. (AH al-8)

Data collected over a period of five generations of selection for low backfat thickness in two Poland China lines showed correlations for backfat probe with percent for lean cuts of $-.44$ in barrows and $-.54$ in gilts. Corresponding correlations with carcass backfat were $-.60$ and $-.37$, respectively. The heritability of backfat thickness was $.41 \pm .09$ from the intrasire regression of offspring on dam. The realized heritability based on the same data was slightly lower, i.e., $.32 \pm .09$. Other heritabilities derived from the intrasire regression of mean of offspring on dam were $.21 \pm .11$ for birth weight; $.17 \pm .07$ for 42-day weight; $.36 \pm .09$ for age at end of test; $.38 \pm .08$ for postweaning daily gain; and $.35 \pm .08$, $.35 \pm .08$, and $.27 \pm .08$ for scores for length, quality, and finish, respectively. Genetic correlations of backfat probes at three sites were $.67 \pm .11$ for shoulder-loin, $.82 \pm .06$ for shoulder-ham, and $.59 \pm .10$ for loin-ham. The genetic correlation between backfat thickness and daily gain was $.35 \pm .13$. (AH al-21)

Litter records collected from 1956 through 1964 on straightbred and crossbred daughters of 35 boars from two strains currently in a reciprocal recurrent selection program were used to obtain sire components of variance and

covariance. Traits studied were litter size and litter weight at birth, 21, and 56 days of age. Three variance components (v.c.) and two covariance components (c.c.) based on comparisons of CC with both SC and SS were available for each of the six traits. One-half of the 18 v.c. were negative, but most of the negative v.c. were smaller than the corresponding c.c. of the same sign. All but three of the 12 c.c. were negative. Due to negative v.c. obtained for some traits, genetic correlations could be calculated only for litter weight at 21 days from comparison of CC with SS and for litter weight at 56 days from comparison of CC with both SC and SS. These correlations were 1.18, $-.38$, and $.61$, respectively. The results obtained suggest that nonadditive gene effects may be important sources of variation in the traits studied. (AH al-13)

B. Selection and Breeding Systems

1. Selection for single traits. Selection responses in tenth generation high- and low-fat Duroc lines and eighth generation high- and low-fat Yorkshire lines were of about the same magnitude as in last year's pigs. Backfat thickness in tenth generation high-fat, low-fat, and control line Duroc pigs averaged 2.06, 1.04, and 1.46 inches, compared with 2.00, 1.18, and 1.52 inches in ninth generation pigs. Eighth generation high-fat, low-fat, and control line Yorkshire pigs averaged 1.47, .92, and 1.18 inches, compared with 1.46, .99, and 1.22 inches in seventh generation pigs. Based on selection responses expressed as deviations from nonselected controls, the realized heritability of backfat thickness at a liveweight of about 175 pounds now stands at $.47$ for both the high- and low-fat Duroc line and at $.35$ and $.52$ for the high- and low-fat Yorkshire lines. Heritabilities calculated from offspring-midparent regressions, using data adjusted for sex differences, date of birth, inbreeding of pig, and weaning weight of pig, had values of $.44$, $.59$, and $.60$ for the high-fat, low-fat, and control line Durocs and $.49$, $.68$, and $.46$ for the high-fat, low-fat, and control line Yorkshires. While backfat thickness does not appear to have reached a plateau in any of the selected lines, both the high- and low-fat Duroc lines have shown a rather marked decline in various components of fitness, with both of these lines now averaging about two pigs less in litter size at weaning than the control line. Conception rates of ninth generation gilts, based on percent farrowing, have also shown a rather marked decline (59%) in the low-fat Duroc line as compared with the high-fat (100%) and control line (88%) gilts. None of the Yorkshire lines, on the other hand, have given any cause for concern as regards their reproductive performance. (AH al-12)

A selection experiment involving a spring and fall replication of five generations of selection for low backfat thickness has been completed. Records on 1,828 animals by 67 sires and from 270 dams were available for study. Inbreeding increased to about 10.8% but its effects were not significant for most traits. Backfat thickness at a liveweight of 175 pounds decreased $.25$ inches in the spring line and $.20$ inches in the fall line. There was no adverse effect on reproductive performance, birth weight, 42-day weight,

age at end of test, daily weight gain, or feed efficiency as a result of the reduction in backfat. Ovulation rate and live embryo counts in samples of gilts slaughtered each generation were not altered with reduction of backfat, although leaner gilts tended to produce more ova. A realized heritability of $.32 \pm .09$ was obtained for backfat thickness. (AH al-21)

A new project has been initiated at one station in which selection for large and small litter size is being practiced in the Duroc and Yorkshire breeds. Litter size is measured by an average of (a) size of dam's first litter, and (b) number of normal appearing embryos in the dam's reproductive tract at 35 days of her second pregnancy. Number of pigs per litter at birth, number of corpora lutea, and number of normal appearing embryos averaged 10.2, 25.1, and 15.8 for Duroc foundation gilts and 11.7, 19.2, and 13.5 for Yorkshire foundation gilts. (AH al-9)

2. Selection for combining ability. Following the pattern established in 1957 for odd-numbered years, fifth cycle litters produced this year in a reciprocal recurrent selection program at Beltsville were the product of intrastrain matings among animals selected on the basis of their cross progeny performance in 1964. The inbreeding of the two strains being used in the project now averages 27% for the LL strain and 13% for the BB strain. Weaning and postweaning data obtained in last year's phase of the fifth cycle showed crossbred BL and LB litters exceeding control LL and control BB litters by 1.8 and 1.6 pigs or by 28 and 29% in litter size at weaning, by 52 and 92 pounds or by 25 and 44% in litter weight at weaning, and by .12 and .18 pounds or by 8 and 12% in daily gain from weaning to a final weight of about 220 pounds. These advantages for fifth cycle crossbred pigs are of about the same magnitude as those observed for fourth cycle crossbreds. (AH al-13)

In the Miles City project, data obtained in 1964 on 30 litters representing all possible crosses among the Montana No. 1 select, Yorkshire select, and Montana No. 1 control strains and 23 straightbred litters divided about equally among the three strains showed crossbred litters exceeding straightbred litters out of the same three kinds of dams by 2.0, 1.1, and .9 pigs or by 26, 9, and 8% in litter size at birth; by 1.5, .3, and 1.3 pigs or by 24, 3, and 19% in litter size at weaning; and by 66, 62, and 47 pounds or by 25, 15, and 17% in litter weight at weaning. Samples of pigs fed from each group under record-of-performance conditions showed advantages of 13 and 8% in daily gain for crossbred pigs out of Yorkshire select and Montana No. 1 control sows with practically no advantage for crossbred pigs out of Montana No. 1 select sows. (AH al-11)

Data collected at North Carolina from five Duroc and eight Yorkshire boars with both purebred and crossbred progeny were used to obtain preliminary estimates of the effectiveness of selection in purebred populations for achieving improvement in crossbred populations. The Duroc and Yorkshire boars had a mean of 31 and 39 purebred and 170 and 98 crossbred pigs, respectively. Genetic correlations between purebred and crossbred progeny means

were .22 and .72 for 154-day weight and .21 and > 1.00 for backfat for the Duroc and Yorkshire boars, respectively. Corresponding rank correlations were .08 and .16 for weight and .67 and .12 for backfat. In addition, the Duroc boars had a mean of 6 purebred and 28 crossbred daughters producing litters. The genetic correlations between purebred and crossbred performance were $-.74$ and < 1.00 for number farrowed and number raised, respectively. The corresponding rank correlations were $-.70$ and $-.70$. The results, especially for litter size, suggest that selection for purebred performance will be relatively ineffective for improving crossbreds.

3. Development and evaluation of inbred lines and crosses. A miniature herd of swine has been established at Beltsville, Maryland, by the Food and Drug Administration for toxicity studies and by the Animal Husbandry Research Division for research in swine genetics. Selection is primarily for a white skin and hair coat and reduced body size. The foundation herd was formed by purchasing 6 boars and 20 sows from the Hormel Institute, Austin, Minnesota, in 1963, and 1 boar and 3 sows from Hanford Laboratories, General Electric Company, Richland, Washington, a contractor for the U. S. Atomic Energy Commission, in 1964. The present herd consists of 8 boars and 40 breeding females. Thirty-seven litters farrowed in 1963 and 1964 averaged 8.0 pigs for litter at birth with 5% classed stillborn. Litter size at 21 and 56 days of age averaged 5.6 pigs (70% survival) and 5.4 pigs (68% survival), respectively. Weights of Hormel, Hanford, and first-cross Hormel x Hanford pigs averaged 1.62, 1.68, and 1.87 pounds at birth; 6.4, 6.2, and 6.4 pounds at 21 days of age; and 17.4, 17.4, and 21.8 pounds at 56 days of age. Pig weights of the three groups were similar at 98 and at 140 days of age. At 9 months of age boars and gilts averaged about 110 pounds, while at 30 months the average weight of boars and open sows was about 66 pounds.

4. Gene pools. A gene pool, comprised of 14 older breeds, has now been completed. A gene pool of new breeds is still being formed. The performance of the gene pool of new breeds has been quite satisfactory with respect to litter size, individual growth rate, and backfat thickness. Plans are under way to have Montana No. 1 and Maryland No. 1 stock available for producing 1966 litters. (AH al-20)

5. Breed evaluation. An effort to improve meatiness in five breeds has resulted in considerable success at one station. Carcass data from 1,377 pigs indicated that (a) the Hampshire excelled in percent ham and loin, area of loin eye, and backfat thickness; (b) the Poland was noticeably better in meatiness but was shorter and had more backfat than the Hampshire; and (c) the Landrace and Yorkshire were quite similar in all measurements, both being superior to the Duroc in percent ham and loin and area of loin eye. Spring and fall pigs differed little in length or backfat, but the fall pigs were superior by .7% in ham and loin and by .28 square inch in loin-eye area. Over a three-year period, little change in carcass length or carcass backfat has occurred, but ham and loin have increased 1.8% and loin-eye area .43 square inch. (AH al-22)

6. Performance and progeny testing. Five central testing stations are now operating in Iowa. A production-tested barrow contest in which a total of \$1,000 in prizes is offered for animals which excel in growth rate and meatiness has been initiated. Approximately 200 barrows will be tested at the Iowa Swine Testing Station at Ames prior to display at the Iowa State Fair in August 1965.

A full scale effort has been initiated at one of the Iowa stations to adopt ultrasonic techniques to field evaluations of meatiness. Approximately 700 barrows from experimental herds will be evaluated with the Bronson Model 12. If a satisfactory technique can be devised, local swine improvement associations plan to purchase additional instruments and carry the program to the field. The university staff will assist in training personnel and in keeping and interpreting records. (AH al-22)

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SWINE - PHYSIOLOGY
Animal Husbandry Research Division, ARS

Problem. Increased efficiency in the production of pork is dependent on the elucidation of the basic mechanisms underlying physiology of growth, reproduction, genetics, and environmental adaptation. Since artificial insemination in swine has a great potential, particular emphasis is needed on basic studies in physiology of reproduction related to the development of an effective and practical program.

New genetic aids for improvement of swine require additional understanding of the physiological processes, particularly those involved in the growth and production of high quality lean meat.

USDA AND COOPERATIVE PROGRAM

This is a continuing program conducted by physiologists, biochemists, and animal husbandmen on basic and applied problems in the physiology of reproduction, artificial insemination, and the physiology of growth and development, particularly with respect to the mechanisms involved in deposition of fat, muscular development, and inborn metabolic differences. The research effort at Beltsville, Maryland, involves (1) the development of basic knowledge on swine physiology using animals with contrasting genetic differences, and (2) studies on reproductive physiology.

Cooperative studies at Missouri and Nebraska, which are part of the Regional Swine Breeding Laboratory program, are also included.

The Federal scientific effort on research in this area totals 2.4 man-years. Of this number, 1.2 is on physiology of reproduction and 1.2 on physiology of growth and development.

PROGRAM OF STATE EXPERIMENT STATIONS

Much of the current program of research in this area is based on the thesis that increased reproductive efficiency in swine is dependent primarily upon an understanding of the nutritional and physiological influences on variability of ovulation rate and embryonic survival. Fundamental studies are under way designed to yield information on endocrine events occurring at the time of ovulation, and physiology of the uterine tract conducive to maximum embryonal survival. The effect of the level of nutrition at various stages of growth and development on ovulation rate and embryonal survival is also being studied.

Artificial insemination shows considerable promise in swine as it has in other species. Problems peculiar to swine must be solved, however, before the technique has practical application. Swine spermatozoa are relatively short-lived in vitro, and the volume and concentration of the ejaculate are

quite variable. These and other problems under study include the effects of the accessory glands on semen quality, and yield and composition of sow's milk and the effect of lactation stress on subsequent reproduction. The NCR-26 regional project is concerned with artificial insemination of swine.

Stress factors under study include high and low ambient temperature, optimum temperature and humidity at different stages of development, and interrelationships of environmental temperature with nutrition and environment. The effects of cooling of males and females on conception rate and prolificacy are also being investigated.

Additional studies in this area, including design of housing and equipment, are being conducted in cooperation with Agricultural Engineering including a new regional project, NC-72, Swine Housing Environment.

State stations are investigating the influence of inbreeding and crossbreeding on physiological mechanisms affecting growth and fertility. One station is studying differences in carcass characteristics between barrows and gilts with particular reference to time and rate of development, and the influence of feeding low levels of hormones on sex-influenced growth pattern. Extensive basic research is concerned with the nutrition and physiology of the developing swine fetus. Changes in total serum protein and serum protein electrophoretic patterns during fetal development are being investigated and histological changes of the gastrointestinal tract as they occur during development of the fetus are being characterized.

The total State scientific effort devoted to swine physiology research is 18.0 professional man-years. An additional 7.5 professional man-years pertain to Area 1 (Animal Biology) and are reported therein.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

A. Physiology of Reproduction

1. Synchronization of estrus. The first work at Beltsville, Maryland, demonstrating effective synchronization of estrus in gilts with 1- α -methylallylthiocarbamoyl-2-methylthiocarbamoylhydrazine (ICI 33,828) (MATCH) is summarized in last year's report. Eighty-seven gilts and sows have been used in two separate experiments. This work included studies of the physiological action of MATCH, effective dosage level, duration of the feeding period, stage of the cycle when treatment was initiated, ovulation rate, fertilization rate, embryo survival, and litter size.

Feeding of the compound on the basis of weight was not essential. The addition of 100 mg. of MATCH to the daily ration of the gilt or sow resulted in good synchronization of estrus. All gilts returned to estrus 4 to 8 days post treatment (93% on either day 5, 6, or 7). All sows treated at the optimum level returned to estrus 5 to 11 days after treatment. No adverse effect on the reproductive performance of sows or gilts has been noted.

Overall conception rate of the treated animals was 74.3% compared to 69% for the controls. Average litter size was 8.3 and 9.0 for treated and controls, respectively.

Further research and field investigations of MATCH are needed. It is an effective research tool and provides for the first time the possibility of a practical way for extensive use of artificial insemination in swine. (AH al-19)

2. Factors influencing estrus and fertility. The reproductive response of the more mature sow to different levels of energy intake before and after breeding was studied in 44 sows. Flushing for approximately two weeks prior to breeding significantly increased average daily gain (1.41 vs. 1.11) but failed to improve ovulation rate (15.0 vs. 16.0) for flushed and nonflushed sows, respectively. Average daily gain was significantly increased (1.8 vs. .93) by continuing sows on the flush ration after breeding. Sows fed the high energy ration before and after breeding had a lower conception rate (76 vs. 100%) and there was some reduction in embryo survival in those sows pregnant at slaughter (59.4 vs. 67.3%). These results suggest that little benefit may be expected from flushing sows and flushing may actually be more harmful than beneficial if extended into early gestation. (AH al-20)

3. Anatomy of the reproductive tract. The angioarchitecture of the internal genitalia of 26 female swine showed the arteries anastomose freely and allow fluid injected into any one artery to flow into other arteries of the genitalia. A similar anastomosis exists in the veins. The study revealed that the so-called utero-ovarian artery does not send a branch to the uterine horn, thus a more descriptive name would be ovarian artery. Also, the artery originating from the umbilical artery might be designated as the uterine instead of the middle uterine artery, as it supplies the entire uterine horn. No cranial uterine artery is found in the pig. The uterine branch of the urogenital artery supplies the cervix and uterine body. These and other findings of this study provide a better understanding and establish a sound basis for further work on the vascular system and its role concerning uterine-ovarian relationship. (AH al-21)

4. Location and cleavage stages of swine ova. Fifty-five gilts and sows representing three breeds were used in a study of ova transport. Swine ova were found to be transported through the oviduct at a faster rate than has been reported for sheep, cattle, and many other mammalian species. Ova passed through the first half of the oviduct very rapidly and were found in the third quarter (which contains the ampullary-isthmic junction) 60 to 75 hours after onset of estrus. The ova then passed through the fourth quarter of the oviduct and entered the uterus between 66 and 90 hours after onset of estrus. This knowledge should facilitate in vivo recovery of uterine ova in developing transfer techniques. (AH al-21)

B. Physiology of Growth and Development

1. Physiological differences under genetic control. Biochemical and hematological measurements were obtained from 56 Durocs and Yorkshires in lines selected for 10 and 8 generations, respectively, on the basis of backfat thickness. Mean difference in backfat thickness between high-fat and low-fat lines was .93 inch for Durocs and .44 inch for Yorkshires. The measurements taken were number of red and white blood cells, hemoglobin, plasma protein, blood glucose, and cholesterol. Red blood cell counts of the control and low line Durocs were higher than the high line Durocs ($P < .01$). Total cholesterol values of the high Duroc line differed significantly from the low Durocs ($P < .05$). An increasing linear trend in total cholesterol was observed from the low to the high backfat lines in the Durocs. These data indicate that physiological differences have been introduced by selection. Further studies using biochemical measurements are needed to examine the possibility of predicting the carcass composition of the market hog at an early age. (AH al-19)

2. Gastrectomized pigs. In cooperative exploratory work with the National Institutes of Health, gastrectomized swine were used to study the influence of the absence of the stomach on degenerative changes in the central nervous system similar to those noted in human patients afflicted with amyotrophic lateral sclerosis. Five pigs were subjected to total gastrectomy and showed transitory clinical symptoms (hypersensitivity, spastic paralysis, unsteady gait) which suggested involvement of the central nervous system. Histological examinations of tissue from three animals have been completed and these showed no apparent differences from controls. All gastrectomized animals developed progressive hypochromic and microcytic anemia. Growth rate of the gastrectomized animals was approximately one-half that of the controls. One pig partially gastrectomized (cardiac and fundus region removed) grew at approximately the same rate as the controls and did not develop anemia. This suggests that the gastric mucosa of the pyloric region of the stomach may secrete a factor (similar to B₁₂ intrinsic factor) which combines with iron and renders it "absorbable" by the mucosa of the gastrointestinal tract. (AH al-19)

3. Lactation in the sow. Six lactating crossbred sows and their litters (adjusted to six pigs each) were used to study the effect of MATCH on lactation. Milk yield was computed by weighing the pigs before and after each of three equally spaced nursings in 12 hours. The pigs were with the sow for the remainder of the 24-hour period. In a 14-day treatment period the sows showed either a partial or complete block to milk letdown. The block to milk letdown could be overcome by intravenous doses of oxytocin. These data suggest that MATCH exerts a pituitary hypothalamic block and that its principal effect in the sow was inhibition of the milk ejection reflex. Further, it points out the problem that would arise if one attempted to synchronize estrus in lactating sows that were nursing piglets. (AH al-19)

4. Anatomy and secretion rate of the thyroid in swine. Tissues ventral to the porcine thyroid were dissected to establish the relationship of these structures to the thyroid gland. Arterial supply and venous drainage of the gland were also determined. Determinations of the release rate of I^{131} from the throid of swine that received daily injections of L-thyroxine were made on 213 animals from the Poland China, Hampshire, Yorkshire, and Duroc breeds. A total of 257 observations are involved. The mean daily thyroid secretion rate for all animals was found to be .29 mg. L-thyroxine per 100 pounds of body weight. Males and females did not differ significantly. The secretion rates were significantly higher in the Yorkshire breed at higher temperatures and in the Poland China breed at lower temperatures. Average daily secretion rates of L-thyroxine per 100 pounds of body weight were higher in pigs 2 to 8 months of age (.41 mg.) than in pigs 10 to 14 months (.19 mg.). Significant positive correlations were found within sex and within breed between daily thyroid secretion rate and daily rate of gain of Poland China males and Yorkshire pigs. No significant association between thyroid activity and gaining ability was observed in Poland China females or Hampshire pigs. (AH al-21)

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SWINE - NUTRITION AND MANAGEMENT
Animal Husbandry Research Division, ARS

Problem. The changing demands of the consumer for pork with a high proportion of lean are requiring major changes in the nutrition and management of swine. Furthermore, the use of materials other than lard has greatly reduced the demand for fat-type hogs. Along with the change in genetic makeup which must be made, basic facts concerning metabolic functions require investigation. Furthermore, the basic nutritional factors which influence growth and carcass composition need to be identified and evaluated. These require information on quantitative and qualitative requirements at various growth stages and the changes in requirements to adjust for altered levels of other nutrients or modified environment. To meet the competition of other foods, including other meats, the nutrition and management of swine must constantly be aimed at improvement of feed and labor efficiency. More recently the dependence on use of pesticides for protection of quality and quantity of the nation's food supply has created a difficult and sensitive problem. Although essential to maximum agricultural production, these chemicals must be used safely to prevent contamination of food or environment with harmful residues.

USDA AND COOPERATIVE PROGRAM

This is a continuing program conducted by biochemists, nutritionists, and animal husbandmen investigating basic and applied problems in swine production related to nutrition, metabolism, and management. Work is in progress at Beltsville, Maryland, and cooperatively with the Agricultural Engineering Research Division, as well as through informal collaborative agreements with the Food and Drug Administration and the Southern Utilization Research and Development Division. There is also a research contract with Purdue University. These studies contribute to the establishment of nutrient and mineral requirements and the relation of different components of the diet to each other; to the development of more efficient and economical rations; to the relation of genetic differences to dietary requirements; to the influence of management practices on total production, and more specifically on pesticide residues in pork products; and to the role swine may have as an experimental animal for the investigation of health and dietary problems in man.

The total Federal scientific effort in this area amounts to 4.6 professional man-years. Of this number, 1.0 is devoted to digestion and metabolism; 0.5 to concentrates, evaluation, and utilization; 1.0 to feeding methods; 1.0 to nutritional requirements; 0.6 to management practices, facilities, and equipment; and 0.5 to environmental stress on nutrient intake and performance.

PROGRAM OF STATE EXPERIMENT STATIONS

Swine nutrition research at the State stations is directed toward expanding

our knowledge on nutrient requirements for growth, gestation and lactation, nutrient interrelationships, and nutrient availability in swine feeds. This work is concerned with developing simplified baby pig starter rations; determining the amounts of amino acids, minerals, vitamins, and energy needed to properly supplement growing-finishing rations based on common dietary ingredients; the influence of protein and energy components of the diet on efficiency of gain and carcass composition; and the effects of level of total nutrient intake before and during the gestation period on ovulation and conception rate, litter size, prenatal mortality, and viability of offspring. New feed additives are being evaluated for growth promoting properties.

Fundamental studies under way are designed to yield information on nutrient absorption and metabolism and digestibility coefficients. The protein components of milk and colostrum are being determined. Techniques that utilize the changes of free amino acid content of the blood plasma as indicators of dietary amino acid deficiencies are being developed.

Various management practices during the growth, gestation, and lactation periods are being evaluated for ways to develop a more efficient and economical swine operation. Methods of restricted and interval feeding are being studied. Other aspects are concerned with space allowance, behavior, type of floor, zone cooling, age of weaning on subsequent performance, and the relative merits of pasture or drylot feeding.

The total State scientific effort devoted to swine nutrition and management is 67.0 professional man-years.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

A. Digestion and Metabolism

The response to different levels of dietary energy by Duroc and Yorkshire lines selected over several generations for either maximum or minimum backfat was measured in two trials. This involved individual feeding trials and physical separation of carcasses from 128 pigs ranging in age from 90 to 400 days. The absolute weights of fat and lean up to 400 days of age were linear for all groups. Restricted energy intake up to 230 days of age reduced the accumulation of lean in low-fat lines by 23 and 20% for Yorkshires and Durocs, respectively. There was little or no reduction in the high-fat lines. The restricted energy intake resulted in a relatively uniform reduction in rate of fat accumulation ranging from 33 to 40% for all lines. The average ages at which pounds of fat exceeded pounds of lean in the carcass were as follows: high-fat Yorks restricted, low-fat Yorks normal, and low-fat Durocs restricted, 38, 36, and 35 weeks, respectively; low-fat Durocs normal, high-fat Durocs restricted, high-fat Yorks normal, and high-fat Durocs normal, 29, 23, 22, and 20 weeks of age, respectively. Low-fat restricted Yorks generally had more lean than fat in the carcass at all ages. Balance trials at 90 and 110 days of age showed that pigs in both York lines consistently retained more nitrogen per unit of retained energy

on the restricted diet than on the normal, while the Duroc lines were more variable in their response. The high-fat Duroc line continued to be the lowest in nitrogen retention (3.14 mg.N/kcal.). Low-fat lines in both breeds made the most rapid and efficient gains up to 230 days of age. Reduced energy intake slowed the rate of gain in all lines, ranging from about 15% in the low Yorks to 25% in the low Durocs. There was a 5% improvement in feed efficiency as a result of energy restriction in all lines except the low Durocs. Efficiency in this line was not affected by the reduction in energy intake. (AH a3-18)

B. Concentrates - Evaluation and Utilization

1. Nutritional quality of cottonseed meal. Further testing of cottonseed meal obtained by solvent extraction with a combination of acetone, hexane, and water supported previous experimental evidence of high nutritional value and extremely low toxicity. The cottonseed meal had been stored for approximately a year without refrigeration. It was compared with a fresh supply of soybean meal, each used as the sole protein concentrate and with a 50-50 combination of the two meals. In spite of the age of the mixed solvent cottonseed meal, it produced gains only slightly but not significantly inferior to those from the soybean meal. The cottonseed-soybean combination gave the same gains as soybean meal alone. (AH a3-19)

2. Detoxification of cottonseed meal. The addition of seven iron compounds to a toxic cottonseed meal diet which was fed to weanling male rats identified two grades of ferrous fumarate, ferric citrate, ferric ammonium citrate, and ferrous sulphate (at 2 g. fe./kg. of diet) as supporting normal growth without evidence of toxicity. Ferric oxide and ferrous oxalate were ineffective as detoxicants. Subsequent experiments with rats and swine suggest that iron compounds may vary slightly in effectiveness as detoxicants but do not otherwise improve protein quality and may decrease palatability of the diet. In another phase of the same experimental series, four lots of six pigs each were fed combinations of soybean meal and toxic cottonseed meal as protein concentrates. Lots which received ratios of soybean meal to toxic cottonseed meal of 100:00, 75:25, and 50:50, showed respective gains of 1.55, 1.70, and 1.60 pounds per day (not significantly different) without any toxic symptoms. However, when the ratio was 25:75, the diet was toxic to four of six pigs. These results indicate that blending soybean meal with toxic cottonseed meal can prevent toxicity and may improve protein quality of the diet. (AH a3-19)

C. Feeding Methods

First results of a test of reproductive performance of gilts which were group-fed three levels of feed intake throughout gestation were reported previously. Indications were that the intermediate allowance (4.5 lb./gilt daily) gave markedly superior performance to either the high level (6.0 lb./gilt daily) or the low level (3.0 lb./gilt daily) in terms of number of pigs weaned per litter. Much of the poor performance was attributed to

uneven feed intake consequent to group feeding. The more greedy gilts on the 6.0 pounds ration became too fat while the least aggressive gilts on the 3.0 pounds ration were quite thin. Under either condition initial litter size was sharply reduced.

For the second gestation period all sows were fed in individual feeding stalls and the three levels of feed were supplemented to provide essentially the same adequate level of vitamins and uniform feed intake by individuals on each prescribed allowance. As a result of these adjustments, weaning data from the fall 1964 farrowing by the same females and spring 1965 farrowing by the next generation of gilts fail to indicate significant differences in terms of initial litter size, weaned pigs per litter, or average weaned weight. The feed saving (over the 6.0 pounds ration) during the gestation period has been approximately 180 and 360 pounds for the 4.5 pounds and 3.0 pounds allowances, respectively. However, gilts from the two latter levels which were self-fed for a lactation period of 42 days ate approximately 50 pounds more feed than their littermates from the 6.0 pounds gestation level. This reduced the net saving to 130 pounds and 310 pounds, respectively. (AH a2-5)

D. Nutritional Requirements - Trace Mineral Requirements and Interrelationships

1. Effects of EDTA on zinc utilization at various levels of calcium and phosphorus. A preliminary small scale test with swine indicated that the chelating agent, ethylene diamine tetra acetic acid (EDTA), increased absorption of dietary zinc (Zn) in the presence of 1.2% calcium (Ca) and .8% phosphorus (P).

Three subsequent experiments with weanling male rats measured the effect of .1% of EDTA added to diets which varied in content of Ca, P, and Zn. Data were obtained on rate of growth, feed efficiency, Zn excretion (fecal and urinary), and Zn storage in hair, bone, and liver. Although the addition of EDTA increased growth rate on all Zn levels studied (9 ppm, 19 ppm, and 38 ppm) and at all levels of Ca and P tested, maximum growth occurred with a balanced ratio of Ca and P and the medium (19 ppm) Zn level. While EDTA also markedly improved growth at the low (9 ppm) level of Zn, the growth rate did not approach the maximum. (AH a3-12)

2. Methods of preventing iron-deficiency anemia of baby pigs. Intramuscular injection of 1 ml. of iron-dextran containing 100 mg./ml. has been routinely given to pigs at birth and again at three weeks of age as a standard anemia preventive for a number of years. The following treatments were assigned to litters in rotation according to birth dates: (1) injectable iron-dextran, (2) a commercial pellet, (3) a commercial block, (4) a mixture of three parts clay to one part ferrous sulphate, and (5) three parts skim milk powder and one part ferrous lactate. Hematocrits taken at 7, 14, 21, and 28 days showed that all treatments afforded some protection, although there were a few exceptions where treatments failed

to respond to iron supplementation. Treatment 3, the commercial block, was least effective in maintaining hematocrit values at 7 days but all litter averages were at satisfactory levels at 21 and 28 days. Treatment 5, the milk powder-ferrous lactate combination, had a higher proportion of borderline readings than the other materials. (AH a3-12)

E. Management Practices, Facilities, and Equipment

1. Nonchemical methods for reducing pesticide residues. Three intensities of cleaning were evaluated as to efficacy of reducing internal parasites in pigs on concrete. Daily washing with a high pressure hose was compared with similar washing at 14-day intervals and with shovelling out excess manure three times weekly. Balanced lots of four pigs were randomly assigned to the three treatments. The treatments were replicated three times with pigs which had not been treated for removal of internal parasites while a fourth replicate had been wormed with a piperazine compound at the start of the experiment. Preliminary fecal samples revealed only light infestation of internal parasites, mainly ascarids. An examination of lungs, livers, and contents of small intestines at slaughter showed a trend toward reduced ascarid numbers with intensity of sanitation. None of the differences were significant although the reduction in adult ascarids was marked. Failure to show significant reductions in ascarids is attributed to the light initial infestation of the parasites. Growth was normal (1.58 lb. av. daily gain) and apparently not influenced by parasites.

2. Tissue residues in swine exposed to pesticides. Preliminary investigations were conducted through informal collaboration with the Pesticide Chemicals Research Branch of the Entomology Research Division. Techniques have been standardized for chemical applications to or on the animal and for biopsies of backfat to permit measurements concerning absorption, retention, and dissipation of residues. Pilot studies with lindane used as a spray for external parasites showed residues in samples of backfat removed by biopsy over a period of six months. Further tests with other swine revealed that lindane residue reached a peak at 4 to 7 days after treatment, and that 28 days after treatment the lindane residue persisted at levels of .1 to .3 ppm in the backfat.

PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS

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Concentrates - Evaluation and Utilization

Stevenson, J. W., Cabell, C. A., and Kincaid, C. M. 1965. Azeotropic solvent extracted cottonseed meals in swine diets. (Abs.) J. Animal Sci. 24:289. (AH a3-19)

Stevenson, J. W., Cabell, C. A., and Kincaid, C. M. 1965. Methods of reducing cottonseed meal toxicity for swine. (Abs.) J. Animal Sci. 24:290. (AH a3-19)

Nutritional Requirements

Cabell, C. A. and Earle, I. P. 1964. Calcium and phosphorus levels and utilization of dietary zinc. (Abs.) J. Animal Sci. 23:869. (AH a3-12)

Earle, I. P. and Stevenson, J. W. 1965. Relation of dietary zinc to composition of sow colostrum and milk. J. Animal Sci. 24:325-328. (AH a3-12)

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PRODUCTION INFLUENCES ON SWINE
Animal Husbandry Research Division, ARS

Problem. Beef, lamb, pork, and poultry are excellent sources of wholesome and digestible animal proteins and fatty acids necessary in maintaining a healthy, appetizing diet. However, these meats must be of high quality, as well as in plentiful supply, if they are to retain their high position and esteem in the minds of consumers. Proper finish, a high proportion of lean, with adequate intramuscular fat, tenderness, full flavor, and color desired by the consumer are the goals the meat producer must strive to attain through breeding, feeding, and management. The quality of cuts and kind of meat are directly reflected in the demand and in the price of the product.

Egg shell strength and yolk quality, strength of wool, fatness, quantity, flavor, color, and tenderness of meat are all known to be influenced by production practices. However, these quality characteristics and many more are not well understood, even though they are of considerable economic importance. Effective measures of evaluating quality differences are of great importance in determining the nature and effect of production practices on the products.

USDA AND COOPERATIVE PROGRAM

This is a continuing program conducted by food product technologists, wool and fiber technologists, biochemists, chemists, physiologists, statisticians, and animal husbandmen engaged in both basic and applied research designed to develop methods and information which will be useful in evaluating quality and quantity of animal products and will be useful in aiding and directing livestock production. Research on beef, veal, lamb, and pork is directed at the influence of selection and breeding, nutrition, physiology, management, and other production variables on carcass and meat quality and quantity. Standards are being applied and adapted for appraisal of slaughter animals, of carcasses, and of meat cuts. The objective of the work with poultry and eggs is to ascertain those factors of nutrition, breeding, and management which contribute to the initial quality of poultry products and their capacity to retain that quality. Studies with wool, fur, and fiber are conducted to determine the physical, chemical, and biological structures and properties of wool and other animal fibers as influenced by production factors. The work is conducted at Beltsville, Maryland; Dubois, Idaho; Fort Wingate, New Mexico; Glendale, Arizona; and in cooperation with four State experiment stations. Cooperation is also carried out with the Eastern and Western Utilization Research and Development Divisions, the Human Nutrition Research Division, the Agricultural Engineering Research Division, and the Market Quality Research Division.

PROGRAM OF STATE EXPERIMENT STATIONS

Pork. A majority of projects discussed in the Nutrition and Management and Breeding problem areas include appraisal of the end product--the carcass. Research at some stations, however, has as its primary objective the influence of varying ratios of protein to energy and total feed consumption on carcass characteristics, and an evaluation of various criteria of selection for superior meat-type swine.

PROGRESS - USDA AND COOPERATIVE PROGRAMS

Pork

1. Tenderness and palatability evaluation techniques. Cross-sectional variations in tenderness were observed among 97 pork loin roasts using the slice tenderness evaluator (STE). The lateral location of the longissimus dorsi muscle in the roasts (3 thoracic and 3 lumbar vertebra) had lower STE values and was markedly more tender than the medial or dorsal locations. However, the less tender medial and dorsal areas gave STE values that correlated more closely with panel score than values for the more tender lateral locations. In a second study of 70 pork loins, the STE accounted for twice the variance in panel tenderness score as that accounted for by the Warner-Bratzler shear, the universally accepted measure of objective tenderness. Pork differed from beef regarding the area of most and least tenderness in the l. dorsi muscle. (AH a4-3)

A study designed to evaluate panel sensitivity to certain organoleptic factors in pork roasts was undertaken. The experimental samples were taken from the carcasses of 128 pigs used in a growth and management study. Breeding and energy restrictions significantly affected the tenderness and other palatability characteristics of pork loins. Duroc pigs were significantly more tender, juicy and generally more desirable than Yorkshire pigs. Ten generations of selection for or against back-fat thickness had no significant effect on palatability scores of the loin. However, when the energy intake was restricted to three-fourths of requirements on one-half of the pigs in the study, the panel rated them much lower in tenderness, juiciness, and overall desirability. They also detected a significant decrease in tenderness with age. Differences in tenderness due to breeding and management, and panel juiciness scores accounted for 69% of the variation in panel overall desirability score. (AH a4-3)

Samples of cooked pork from 46 pork loins were studied for centrifugally expressed moisture (CEM) water-holding capacity using a technique recently developed by this Laboratory. Although the CEM values did not directly reflect the juiciness of the meat as measured by taste panel, the means were usually higher for samples receiving higher juice quantity scores.

Pork samples that were moderately juicy, slightly dry, and dry gave CEM values of 16.1, 16.4 and 14.8% moisture extracted. There appears to be two types of juiciness, one in which the meat is incapable of retaining the moisture in the tissues and another that is slightly lower in moisture after cooking. In the former type, the juice is "watery" and is lost just as the meat is sliced for serving, while in the latter type, there is an excessive loss of moisture during storage and cooking. This would account for the discrepancy between juiciness scores and CEM values noted for pork. (AH a4-3)

2. Carcass evaluation. A least squares analysis of 23 pork carcass and cut linear measurements on 97 hogs slaughtered at 50-pound intervals from 75 to 275 pounds, has been completed. The carcass and cut measurements included length, depth, and width -- all taken from definite anatomical locations. Mean differences between weight groups were statistically significant for all measurements. When the data were pooled for each, the mean differences between barrows and gilts were significant for width of shoulder and ham, and length of loin. (AH a4-3)

An extensive statistical analysis is being made of growth data from 56 Poland China pigs divided into two groups according to degree of finish. Preliminary analysis indicates that different muscles have significantly different rates of development when plotted against total lean. There is apparently no significant difference between rates of growth of the same muscle for the two groups, although there is a definite individual muscle weight difference at each age interval. (AH a4-3)

3. Color. Research on color in pork as influenced by heredity, sex, age, feeding, and management was continued as a PL 480 study with the Institute of Animal Physiology and Nutrition Laboratory of Animal Products, Polish Academy of Science, Warsaw, Poland. The results show that color of meat is determined by several physical and chemical properties. The major ones are pigment content, water-holding capacity, pH, and moisture content. The dominant wavelength of light in meat color depends on pH. Saturation is determined by content of pigments, water-holding capacity, and moisture content. Lightness is conditioned by water-holding capacity, concentration of pigments, and pH. Color stability of raw meat is dependent on its water-holding capacity and reducing activity. A high relationship between color stability and water-soluble SH-groups points to the part played by those groups in post-mortem color changes in meat.

No significant relationship was detected between accommodations (reared in sties vs. paddocks with huts) and associated properties of the meat. Feeding on different kinds of rations (barley, rye, potatoes, etc.) did not result in differences in color, provided the ration was equalized with respect to energy and protein level.

Pigs display considerable differentiation in respect to post-mortem lactic acid production in the carcasses. Lightness of color was the only color attribute associated with pH measured 45 minutes after slaughter.

There was no relationship between protein-bound iodine in the serum of pigs and pH measured 45 minutes post-mortem. This indicates that contrary to some opinions the reason for meat being pale, soft, and exudative are not to be found in a weakened action of the animal's thyroid. (E 21-AH-2)

PUBLICATIONS - USDA AND COOPERATIVE PROGRAMS

Pork

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Hiner, R. L., Thornton, J. W., and Alsmeyer, R. H. 1965. Palatability and quantity of pork as influenced by breed and fatness. J. Food Sci. 30(3):550-555. (AH a4-1)

Thornton, J. W., Alsmeyer, R. H., and Davey, R. J. 1965. Genetics, diet and pig age effects on pork quality. J. Animal Sci. 24(3):869. (Abs.) (AH a4-1)

INFECTIOUS AND NON-INFECTIOUS DISEASES OF SWINE
Animal Disease and Parasite Research Division, ARS

Problem. Profitable swine production depends largely on the ability to control diseases. Swine diseases cause losses estimated at more than \$200 million annually. In order to control and eventually eradicate these diseases, a thorough knowledge of causes, diagnostic procedures, preventive procedures, and treatments is required. Although a great deal of excellent research has been and is being accomplished, a vast amount of research is still required to obtain this knowledge. At present, the causes of several important swine diseases are unknown or incompletely understood. Extensive fundamental research on swine diseases is essential to the welfare of the swine industry.

USDA AND COOPERATIVE PROGRAM

The Department has a long history of swine disease research. For example, research on hog cholera was initiated in 1884. Research on this and other important swine diseases is a continuing long-term program. Modern research techniques in the areas of biochemistry, biophysics, pathology, microbiology, pharmacology, physiology, and immunology, are being applied to swine disease problems. Research is being conducted on the following diseases at the designated locations.

The Federal scientific effort devoted to research in this area totals 14.2 professional man-years. This effort is divided among sub-headings as follows:

Hog Cholera 6.4 at the National Animal Disease Laboratory, Ames, Iowa, the Florida Hog Cholera Research Station, Live Oak, Florida, under a cooperative agreement with the University of Illinois, and under a contract with the University of Nebraska.

Atrophic Rhinitis 2.0 at the National Animal Disease Laboratory, Ames, Iowa.

Transmissible Gastroenteritis 2.3 at the National Animal Disease Laboratory, Ames, Iowa, and under cooperative agreements with Purdue University and the University of California.

Erysipelas 1.5 at the National Animal Disease Laboratory, Ames, Iowa.

Brucellosis 1.0 at the National Animal Disease Laboratory, Ames, Iowa.

Abscesses 1.0 at the National Animal Disease Laboratory, Ames, Iowa.

PROGRAM OF STATE EXPERIMENT STATIONS

Swine disease research at the State stations involves a continuing program of investigations to bring about improved means of control for the major problems present in this country. A considerable amount of this effort involves basic research aimed at providing new information applicable to a more complete understanding of these problems.

Swine enteritis is receiving particular attention through a coordinated attack by means of the regional research program (NC-62). Ten States and the Department are cooperating on various phases of this problem.

Respiratory diseases such as atrophic rhinitis, virus pig pneumonia and influenza are under study at several locations. The Specific Pathogen-Free system of controlling these conditions is undergoing evaluation for further improving this disease control method. Germ-free pigs are being used by several stations in studying enteric and respiratory diseases of swine.

Investigations are continuing in order to find improved methods for diagnosis and vaccination against hog cholera. Renewed efforts are being made to develop procedures which may be found practical in controlling jowl abscesses of swine.

The role of sensitization phenomena in causing the arthritic form of erysipelas is under study. The cause of gastric ulcers, and means of preventing them, are being determined. The toxicity of certain agricultural chemicals for swine is under investigation.

The total State scientific effort devoted to swine research is 42.0 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Hog Cholera

Research at the National Animal Disease Laboratory, Ames, Iowa, was conducted in the following phases:

1. Inactivation of Hog Cholera Virus in Blood and Excreta with Chemical Disinfectants. Of 13 chemical agents tested, only one chemical, beta-propiolactone, 0.6%, inactivated the virus in defibrinated blood with a titer of 7.5×10^5 /ml. Wheaton's Safety Disinfectant, 1%, was the only one of the other 12 chemicals which killed the virus in blood diluted 50%. Roccal, 2%; cresol, 2%; sodium hydroxide, 2%, and sodium hypochlorite, 1%, killed the virus in 10% blood. The other 8 compounds tested, Nolvasan, Clorox, septisol, sodium carbonate, ethyl alcohol, formaldehyde, phenol, and isopropyl, were either only partially effective or had no effect on the virulence of the virus.

Beta-propiolactone, 0.15%; Wheaton's Safety Disinfectant, 0.5%; Roccal, 2%; cresol, 2%, and sodium hydroxide, 2%, killed hog cholera virus in fecal suspensions. Sodium hydroxide, 3%, did not kill hog cholera virus in defibrinated blood.

Except for sodium hydroxide, none of the effective agents gave extreme pH values. Three of the inactivating agents were effective in diluted blood at pH values near neutrality.

2. Diagnosis of Hog Cholera. A field evaluation study, started in 1963, of the fluorescent antibody-tissue culture test (FATCT) for the routine diagnosis of hog cholera (HC) has been completed. FATCT was found to be an effective method for HC diagnosis. However, information gained from this study indicates that the inoculation of HC susceptible swine with suspect material is a more sensitive diagnostic procedure than FATCT. In all instances the identification of HC virus by FATCT was subsequently confirmed by animal inoculation (228 outbreaks), whereas a diagnosis of HC was made by animal inoculation but not FATCT with tissue samples from 8 suspected outbreaks of HC. The final correlation between the two tests was 96.6 percent.

It was suspected that tissue culture cells were less susceptible than swine to infection with HC virus. To test this hypothesis, a comparative titration was performed employing the Ames strain of HC virus. The same dilutions of virus were injected into specific-pathogen-free (SPF) swine and onto cells of the PK-15 swine kidney cell line. Titers were $10^{6.64}$ and $10^{7.17}$ for tissue culture and swine, respectively. The results would thus tend to support the hypothesis. However, it must be emphasized that only one comparative titration was performed employing a single strain of HC virus.

Spleen tissue was superior to blood for conducting FATCT. Hog cholera virus was isolated and identified from 91% of all spleens received from confirmed cases of HC, whereas HC virus was isolated from only 60% of the blood samples.

Since HC virus was not identified by FATCT from a significant percentage of spleens (9%) submitted from swine herds where HC was known to exist, it was concluded that multiple sampling is of paramount importance, that is, two or more spleens should be submitted from any suspected outbreak.

(Ames, Iowa. NADL) (ADP a2-17)

In research being carried out under a cooperative agreement at the University of Illinois, Urbana, the basic observation was made on the effect of high oxygen concentration on cytopathogenicity of hog cholera virus in tissue cultures. Briefly, it was found that rabbit testicular cell cultures inoculated with spleen extracts or blood derived from pigs infected with hog cholera virus showed marked cellular destruction after incubation at 37 C in an atmosphere of 95% oxygen and 5% carbon dioxide, at a pressure of 5, 10, or 15 pounds per square inch. No cellular destruction was observed in

cultures similarly inoculated, but incubated at normal atmospheric pressure, nor in uninoculated cultures that were incubated under increased O_2 - CO_2 pressure. That the cytopathic effect (CPE) observed in cultures inoculated with hog cholera virus was indeed caused by the virus was confirmed by the finding that CPE was prevented by hog cholera antiserum but not by normal swine serum. However, it was not possible to reproduce the CPE for more than a few serial passages utilizing the fluid of tissue cultures in which CPE had been induced by hog cholera virus. This observation suggested that the CPE was caused by a cytotoxin either associated with the virus or produced by the virus-infected cells, and that the expression of CPE was not accompanied by viral replication. (Urbana, Illinois)

In research conducted under contract at the University of Nebraska, Lincoln, a highly promising test for the diagnosis of hog cholera using a fluorescent antibody staining technique has been developed. The test is accomplished directly on fresh tissues such as tonsil, lymph nodes, salivary gland, and kidney. In experimental cases, hog cholera virus could be detected in the tonsil as early as 72 hours after exposure. (Lincoln, Nebraska)

3. Chromosomal variations in a pig kidney cell line persistently infected with hog cholera virus. In work at the National Animal Disease Laboratory, Ames, the number of chromosomes occurring most frequently (modal number) has been determined for two pig kidney tissue culture cell lines (both designated PK-15) from two different sources. The majority of the cultured cells of the PK-15(NADL) cell line contained 38 chromosomes, the same number found in the living pig. In contrast, the majority of cultured cells of the PK-15(ATCC) cell line contained 37 chromosomes, one less than typical for the living pig. Both of the PK-15 cell lines contained a large, unmatched, identifying chromosome.

A pig kidney cell line, with cells, most of which contained 38 chromosomes, was infected with virulent hog cholera virus and subcultured 84 times. The continued presence of hog cholera virus during subculturing was confirmed by a specific staining test. Chromosome studies were made on cells prepared at the 82nd subculture, and the findings compared with noninfected cells subcultured in a similar fashion. It was found that most of the infected cells contained 37 chromosomes. In those cells containing 37 chromosomes some of the groups were observed to have lost one or more chromosomes and this was accompanied by the simultaneous appearance of new unpaired chromosomes in other groups. Even though there were numerous chromosomal rearrangements in the infected cells, a large identifying "marker" chromosome present in the noninfected cells was also observed in the infected cells. (NADL)

4. Soluble antigens of hog cholera and bovine viral diarrhea viruses. Partially purified soluble antigens of hog cholera -- and bovine viral diarrhea -- infected tissue cultures were prepared by freeing crude preparations of most of the infective virus.

When the hog cholera and bovine viral diarrhea soluble antigens were tested in agar-gel plates with either hog cholera or bovine viral diarrhea antiserum, a continuous line of precipitation was obtained. The specificity of the reactions was confirmed by the fact that the test antigens did not react with nonimmune sera and the antisera did not react with control antigens prepared from noninfected control antigens. (NADL) (ADP a2-17(C))

5. Pilot field studies to evaluate diagnostic tests, biologic products, and quarantine measures for a hog cholera eradication program. Preliminary exploratory studies were conducted on reactions of pigs to sublethal doses of virulent hog cholera virus. The object of these studies was to establish a foundation of experimental evidence for further research on the immunizing effect of repeated, increasingly larger but sublethal doses of virulent hog cholera virus on swine, to demonstrate the variations in reactions in different swine associated with exposure or challenge with minimal infecting doses of virus and to present other uses of minimal infecting doses of live virus in swine such as for virus characterization.

Sixty-two pigs and two strains of virus were used in these studies. Thirty-one pigs died with symptoms and lesions at necropsy usually associated with hog cholera following the first exposure to hog cholera virus. These pigs were considered to have been non-immune (susceptible). The other 31 pigs survived the initial exposure to hog cholera virus and were given increasingly larger but sublethal doses of virus. Twenty-one of these also survived one or more subsequent exposure to hog cholera virus but did not develop complete immunity. Upon exposure to greater doses of virus, they developed hog cholera and died. These pigs were considered to have been partially immune. Five of these 21 pigs, all of which had been treated with the same strain of virus, had hog cholera reactions following doses of diluted virus and recovered. Upon challenge with larger doses of virus, however, they were found not to have developed complete immunity. In other words, the hog cholera reaction in these five pigs did not indicate an immune response and may have indicated a characteristic of this particular strain of virus.

Ten pigs survived the initial exposure and subsequent exposures to diluted but increasingly larger doses of virus and developed complete immunity. This was demonstrated by their survival following subsequent challenge exposure to 1.0 ml. of undiluted, virulent hog cholera virus.

Hog cholera virus in order to be pathogenic for swine seemed to require a quantitative minimum (particulate) as well as a qualitative minimum (virulence) of virus.

The pilot hog cholera (HC) eradication project in Lowndes County, Georgia, was initiated December 29, 1961, and was terminated 30 months later on July 31, 1964. The objectives of the study were to test the efficacy of killed HC virus vaccines for eliminating HC virus from an area of known infection and to develop methods of identifying and preventing virus

reintroduction and dispersion following virus elimination. The vaccination program consisted of 3 periods - 1) initial government-paid vaccination of all swine in the county within a 2-month period; 2) government-paid vaccination of swine increases for 25 months and starting with the 2nd month of initial vaccination, and 3) owner-paid vaccination for 4 months.

The results of the field trial study demonstrated that a high population protection level (83.7%) against hog cholera was initially obtained during the first period with 93.0% vaccination coverage of all swine multiplied by the 90.0% immunity obtained at that time, with two 5 ml. doses of killed-virus vaccine. This procedure rapidly eliminated clinical hog cholera from the test area. However, evidence of nonclinical hog cholera, measured by the resistance to challenge with virulent HC virus of nonvaccinated controls left in vaccinated herds, continued to persist in 4 of 29 herds tested during 6 months of the second vaccination period. There were 41 of 41 non-vaccinated controls, each from different herds, which showed no resistance to HC virus challenge during the next 8 months, which indicated clinical and nonclinical HC virus had been eliminated. During this time, the swine population protection level against HC dropped from 83.7% to 40.0% because of a decline in swine vaccinations that continued throughout the rest of the project period, while immunity levels remained relatively constant.

During the last 11 months of the second vaccination period, as the population protection level dropped from 40.0% to 18.0%, and the third vaccination period of 4 months when the population protection level dropped from 18.0% to 10.0%, 6 of 53 vaccinated herds were positive for nonclinical hog cholera. This incidence suggested sources of HC virus introduction into the area.

The simultaneous vaccination of market swine, with killed vaccine and anti-HC serum, before movement to test area farms was an effective method of controlling the dispersion of HC virus from markets to Lowndes County farms. No clinical or nonclinical positive HC was identified in herds receiving purchased swine even though 42 outbreaks of HC occurred in adjoining counties during the test period.

The average immunity protection of 2007 killed HC virus vaccinated swine challenged with virulent HC virus, was 77.1 percent. Double vaccination with killed-virus vaccines produced better immunity protection (78.7%) than did double vaccination with killed-virus vaccines and anti-HC serum (73.6%) or single vaccination (68.8%). The duration of immunity from double vaccination at 10 months postvaccination (76.9%) was superior to single vaccination (56.6%). Double vaccination of weanlings gave better immunity protection (84.6%) than the double vaccination of suckling-weanlings (69.1%) or sucklings (69.6%) as compared with the single vaccination immunity protection of weanlings (70.1%) and sucklings (58.7%).

(Live Oak, Florida) (ADP a2-13)

B. Atrophic Rhinitis

At the National Animal Disease Laboratory, Ames, Iowa, research on atrophic rhinitis (AR) of swine was reinitiated during the year. The work of the laboratory personnel was applied to solving basic problems of raising specific-pathogen-free hysterectomy-derived pigs, developing tissue culture cell lines, and developing isolation and identification procedures for bacteria. These various techniques and methods will be used as tools to identify the causes of AR. (NADL)(ADP a2-8)

C. Transmissible Gastroenteritis (TGE)

At the National Animal Disease Laboratory, Ames, Iowa, five isolates of transmissible gastroenteritis (TGE) from different geographical areas have been studied and compared. All isolates studied have a common cytopathic virus which has biological properties which indicate that it belongs to the myxovirus class. Concurrent research indicates that this cytopathic virus is not the most important virus involved in TGE, but it appears to be present in many of the outbreaks of TGE which have been studied, and most TGE convalescent serum samples from outbreaks in the field contain antibodies which will neutralize the cytopathic virus.

Evidence of the cytopathic virus can be removed by the use of specific homologous antiserum. Cell cultures so treated remain pathogenic for pigs, however. When the cytopathic virus is purified by plaque picking techniques it is also pathogenic for pigs. Either virus alone seems to produce a somewhat different disease in susceptible pigs than is expected from feeding virus-bearing intestinal tissue or primary swine kidney cultures containing both viruses. (NADL) (ADP a2-10)

At Purdue University, Lafayette, Indiana, under a cooperative agreement, further investigation into the pathogenesis of transmissible gastroenteritis (TGE) showed that this virus caused a severe and rapid atrophy of the intestinal villi of pigs. The villi are hair-like projections lining the entire small intestine and are essential to the digestion and absorption of nutrients. The extent of the change was observed by using an instrument designed at this laboratory which permits examining the entire intestine under a dissecting microscope in a relatively short time. The lesions were also examined by measurement of villi and characterization of the cellular changes in microscopic sections of pigs killed at all stages of the disease. The results of this work showed that villi were atrophied throughout the small intestine except for the first few inches without observable inflammatory reaction within 24 to 48 hours after inoculation of virus. The cells covering the remaining stubs of villi were not differentiated into the normal columnar cells. Villus atrophy was correlated with decreased ability to absorb orally administered glucose. The possibility that this change was the result of inhibition of cell multiplication by the virus was eliminated by counts of mitotic figures after administration of colchicine to infected pigs. Mitotic activity in the intestinal mucosa was increased in these pigs.

Villi showed beginning re-growth in pigs killed as early as 5 days after infection and apparently returned to functional normalcy through the next few days. This was correlated with cessation of diarrhea.

The results of this work would characterize TGE as an acute malabsorptive disease caused by a virus. This information will contribute to the diagnosis and ultimate development of treatment of TGE and, additionally, is a contribution to the understanding of diarrheal disease in general.

Work on immunity extended previously reported work on the mechanism of transfer of passive immunity to TGE from sows to pigs. It was shown that pigs which had suckled immune sows and, therefore, had absorbed antibody from these sows were as susceptible, after removal from those sows, to minimal doses of virus as pigs which had suckled non-immune sows. Pigs left to suckle immune sows were resistant to 1000 times as much virus as that which infected those removed from them. This passive immunity then, must result from inactivation of virus by antibody in milk within the lumen of the alimentary tract. This, as far as is known, is the first proof of this type of transfer of passive immunity. The term "lactogenic immunity" is used to describe it. (Lafayette, Indiana)

In work at the School of Veterinary Medicine, University of California, Davis, under a cooperative agreement with the USDA, the Chico strain of enterovirus was isolated from pigs in a herd showing signs of vomiting and diarrhea with a negligible mortality.

No symptoms could be demonstrated in naturally reared pigs inoculated by any route under normal experimental conditions but when inoculated pigs were exposed to 15 or 30% CO₂ in air following intravenous and oral inoculation, signs of vomiting and diarrhea were reproduced.

Specific-pathogen-free (SPF) pigs inoculated with the Chico virus intravenously and exposed to a CO₂ atmosphere, resulted in a nervous disorder as well as vomiting and diarrhea. Previous trials in SPF pigs in the absence of stress did not result in any visible signs following any route other than the intracerebral route.

Expose of pigs to CO₂ atmosphere following infection with strain E1 enterovirus did not influence the course of the disease syndrome which was caused by the virus in the absence of stress. (Davis, California) (ADP a2-10)

D. Erysipelas

At the National Animal Disease Laboratory, Ames, Iowa, a summarization of "Physiopathological Studies of Erysipelas in Pigs" was submitted for the year 1964, and the article published in January of 1965.

Serotypes A, B, and N of Erysipelothrix rhusiopathiae have been isolated from a variety of domestic animals and fish and in turn have been related to clinical aspects of swine erysipelas and animal species. Thus, the use

of serotyping could increase the knowledge of the epizootiology of swine erysipelas if the organism retained its particular serotype after passing through the host. Some published reports indicated that a change in serotypes occurred after repeated transfers in liquid medium and after numerous passages in mice. An assumption was made that this could occur in pigs. From the results of a study at this laboratory, it was concluded that 1) no change occurred in the serotype of strains after passage through either susceptible pigs or ones that had been immunized with either killed cells of a homologous or heterologous type, and 2) no change occurred in the serotype after storage on solid medium at room temperature for approximately 3 months.

Arthritis in pigs can be a sequela of acute swine erysipelas and constitutes a sign of the chronic form of the disease. Some researchers believed that arthritis also can appear in healthy farm pigs with no history of swine erysipelas and suggest that arthritis is an independent form of the disease. Others believed that arthritis can be the result of hypersensitization to Erysipelothrix rhusiopathiae. The latter aspect has received considerable attention because of implications with human arthritis, but experimental evidence to support the relationship between arthritis and hypersensitization in pigs has not been conclusive. An objective of one study was to determine in specific-pathogen-free pigs if the arthritis associated with erysipelas is caused primarily by local infection or by sensitization. From the results of this series of experiments it was concluded that 1) the arthritis of swine erysipelas is caused by specific infection rather than hypersensitivity; 2) there was no significant relationship between the serotype of the challenge and the incidence of arthritis in immunized pigs; 3) the degree of virulence was not necessarily associated with the ability of an organism to induce arthritis in immunized pigs, and 4) arthritis occurring in immunized pigs supports the field observations that arthritis is seen in pigs with no apparent history of swine erysipelas.

Failure to recover the organism from some joints has been explained as due possibly to 1) its elimination by natural processes; 2) localization in an area not reached by the swab, and 3) localization in an area not opened for examination. The significance of items 2 and 3 was demonstrated when the known, but heretofore overlooked anatomical structure of the carpus and tarsus was reviewed. The carpus has 3 synovial sacs and the tarsus has 4, and all do not communicate, so that infection in one sac would not necessarily involve the other sacs. Thus, when histologic preparations are made, a sagittal section through the entire articulation should include all the synovial sacs and the bacteriologic examination should include material from more than one synovial sac.

(NADL)

(ADP a2-15)

E. Brucellosis

At the National Animal Disease Laboratory, Ames, Iowa, the following work is reported.

Since the pathogenesis of swine brucellosis has not been thoroughly investigated, an experiment designed to gain more information about that aspect of the disease was conducted. Seven sexually mature boars were exposed to a representative strain of Brucella suis, type 1, and seven to a representative strain of Br. suis, type 3. One boar from each group was killed at each of the following postexposure intervals - 1, 2, 3, 4, 6, 8, and 12 weeks.

Severe clinical signs of the disease occurred in only a few boars and these signs were attributed to pathologic changes occurring in accessory genital glands.

Agglutinins appeared in detectable amounts in the serum of boars about one week postexposure, reached their maximum at two weeks, then gradually receded thereafter. The presence of Brucella agglutinins was also demonstrated in secretions or exudates from seminal vesicles bearing gross lesions. All boars experienced a period of sustained brucellemia after exposure.

At necropsy, 75% of the Br. suis isolations were made from lymph nodes, 15% from the urogenital system, and 10% from other tissues. Gross pathologic changes attributable to both types of Br. suis were primarily confined to seminal vesicles and their regional lymph nodes. Histopathologic alterations were most frequently observed in lymph nodes, liver, accessory genital glands, and bones of infected boars. All anatomic systems were represented in the bacteriologic and pathologic examinations.

The period of maximum infection extended from 2 through 6 weeks post-exposure with 92% of the Br. suis isolations and 82% of the histopathologic alterations occurring in boars killed during that period. The disease produced by Br. suis in boars could be classified as a subacute to chronic, proliferative disease affecting primarily the reticuloendothelial system and accessory genital glands.

Since brucellosis is often a venereal disease in swine, one of the most important reservoirs of the disease is breeding herds. Considerable information has been gained through conducting this experiment on the pathogenesis of brucellosis in boars. A similar study should be conducted with female swine, with particular emphasis on changes in the genital tracts of pregnant females infected with Br. suis. (NADL) (ADP a2-16)

F. Abscesses

Research on abscesses in swine has been under way at the National Animal Disease Laboratory at Ames, Iowa, during the past year but the results have not progressed to the reporting stage. (NADL) (ADP a2-19)

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Brucellosis

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FOOT-AND-MOUTH AND OTHER EXOTIC DISEASES OF SWINE
Animal Disease and Parasite Research Division, ARS

Problem. Foreign diseases, such as foot-and-mouth disease, African swine fever, and Teschen disease, that occur elsewhere in the world, constitute calculable potential threats to the swine industry of the United States. Foot-and-mouth disease is of particular importance because the disease frequently occurs primarily in swine from which it spreads to other susceptible species, such as cattle and other ruminants. African swine fever, which until recently was confined to wild and domestic pigs in Africa, has spread to Portugal, Spain, and France. The disease is of special concern because of its resemblance to hog cholera, with which it may be confused. Moreover, mortality from the disease approaches 100 per cent, and there is no specific preventive vaccine. Teschen disease, which causes widespread inapparent infections and occasional involvement of the central nervous system, is another of the foreign diseases to be guarded against. A disease indistinguishable from Teschen disease has appeared in England in recent years. Despite all precautions, any of these diseases may occur in the United States, as likely as not through the medium of modern, rapid international transportation. The Plum Island Animal Disease Laboratory is engaged in studies of foreign diseases of swine for the purpose of developing information for increased protection of the Nation's swine industry.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving veterinarians, biochemists, microbiologists, and pathologists, engaged in basic and applied research in this problem area. Research is being conducted on the following diseases at the designated locations.

The Federal scientific effort devoted to research in this area totals 4.0 professional man-years. This effort is divided among sub-headings as follows:

Foot-and-Mouth Disease of Swine 1.0 at the Plum Island Animal Disease Laboratory, Greenport, Long Island, New York.

African Swine Fever 3.0 at the Plum Island Animal Disease Laboratory in cooperation with the East African Veterinary Research Organization, Muguga, Kenya, and in connection with a PL 480 project in Madrid, Spain.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Foot-and-Mouth Disease of Swine

At the Plum Island Animal Disease Laboratory, studies in swine with foot-and-mouth disease virus (FMDV), type C-3 CANEFA, indicate that this virus appears to have an affinity for swine and causes extensive myocardial damage.

The modified strain tested has not been satisfactory either in quantity of endurance or antibody produced. Chemically treated baby hamster kidney (BHK) cell culture virus, combined with a Freund's adjuvant (incomplete), shows promise of protecting swine against exposure to homologous virus for at least 90 days, and in some cases, 180 days.

Recovered swine exposed to a homologous virus may become infected.
(PIADL) (ADP a9-1)

B. African Swine Fever (ASF)

Researchers at the Plum Island Animal Disease Laboratory and at the East African Veterinary Research Organization laboratory at Muguga, Kenya, report as follows:

The stable line of baby hamster kidney cells (BHK 23) is extremely prolific and ASF isolates were readily adapted to them. Virus proliferation progresses at a rate approximately double that obtained in other stable cell lines or primary cultures of pig kidney (PK) cells. Cultures in Povitsky bottles have been used to produce liter quantities of fluids containing about 10^7 TCID₅₀/ml. This has served as an ample source of virus for purification trials, fractionation of viral antigens and inactivation studies.

The Tengani isolate, passaged 45 times in buffy coat cultures followed by 40-45 passages in BHK 23 cells, has been modified sufficiently to cause non-fatal infections in pigs. Two of these animals have subsequently survived inoculation with fully virulent Tengani virus. Their sera contained African Swine fever virus (ASFV) antibodies which are demonstrable by complement-fixation and agar-gel diffusion precipitin tests.

African swine fever virus, Tengani, was passaged rapidly, 121 times in buffy coat cultures at daily intervals. Criteria for attenuation was the response of pigs inoculated with virus at passage levels 30, 40, 51, 63, and 121. Pigs inoculated with all passage levels were either moribund or dead within 13 days after inoculation. Neither the virulence of the virus nor the character of the lesions was modified by serial passage.

To date, 39 passages have been completed in PK 13 cell cultures with the 14th passage of the Hinde isolate in primary pig kidney cell cultures. Originally, from 7-12 days were required to obtain cytopathic changes in inoculated cultures of PK 13 cells but following 6 or 7 passages, cytopathic changes took place in 3-5 days, depending upon the concentration of the inoculum. The second passage of Hinde PK 14 virus was inoculated into pigs but showed no attenuation.

Cultures prepared with the PK 13 cell line and primary pig kidney cells had been used successfully to titrate the infectivity of the passage viruses.

Sera obtained from pigs surviving both inoculation with tissue culture passage and challenge virus were tested, likewise, but were devoid of virus neutralizing antibodies.

Lambs and guinea pigs inoculated repeatedly with Hinde tissue culture virus failed to develop virus-neutralizing antibodies.

Attempts to produce plaques using overlay medium prepared with Noble's agar, ion agar and hydrolysed starch failed, although in several instances some cytopathic effect was observed underneath the overlay.

Successive stages in the development of the virus particle propagated in PK 13 and primary pig kidney cultures have been examined in thin sections by the electron microscope. The mature particle has a hexagonal outer membrane structure (diam. 175-215 m/ μ) surrounding an electron lucent region and a dense nucleoid (diam. 72-89 m/ μ). The increase in particle production in the cell cytoplasm is consistent with both the rise in infectivity of culture fluids in pig kidney cells and the rise of the haemadsorption titer in leukocyte cultures.

Attempts to purify ASFV for studies of free virus by electron microscopy have, thus far, been unsuccessful. The virus particles are apparently intimately associated with the host tissue. All methods of separation assayed have proven to be injurious to the virus.

The Tengani isolate of ASFV grown on BHK cells was fractionated to separate the virus from the soluble noninfectious antigens. Each of the fractions was inoculated into rabbits and the sera obtained from rabbits are being tested for their ability to neutralize the Tengani virus and other isolates.

Each of the fractions will be analyzed for phosphorous, nitrogen, ribose, desoxyribose nucleic acids and carbohydrates, etc., to ascertain the biochemical identity of the fractions.

Kidneys from 2 pigs which died from an acute infection with ASFV were fractionated. When the tissue homogenate was dialyzed at pH 5.0 against a buffer of low ionic strength, a precipitate was formed which contained complement-fixing antigen. Another complement-fixing antigen was also found in the supernatant fluid. This soluble antigen can be concentrated by the addition of 50% ethanol to yield an antigen that has a complement-fixing titer in excess of 1:300 when tested against convalescent ASF swine sera. The pH 5.0 soluble fraction from ASFV-infected tissue culture fluid contained antigens which were isolate specific. Should this observation hold true for antigens derived from pig tissues, the procedure may be useful for virus typing studies.

Hemadsorption capability of ASFV could be destroyed in 60 minutes at 37 C using 0.05% B-propiolactone, acetyleneimine and glycedaldehyde. There was no detectable change in the complement-fixing activity following treatment.

Pepsin, trypsin, and papain at concentrations of 0.1 mg/ml., and for 3 hours at 37 C, did not alter the infectivity of ASFV. Complement-fixing activity of the virus was reduced only in the case of papain. Further enzymic studies are planned employing other enzymes and a lower pH range for pepsin.

The virus of ASF was not infective for pigs after exposure to ethylene oxide gas but pigs were infected when given challenge inoculation with 10^2 pig lethal doses of virulent ASFV.

The effect of stress, induced by FMDV, attenuated hog cholera virus (AHCV) and rinderpest virus RV) on pigs previously inoculated with attenuated African swine fever virus (AASFV) was studied. Prior to infection with these viruses, all pigs used in the trials were inoculated intramuscularly with 1 ml of ASFV Lisbon 60 passaged 81 times in pig bone-marrow cell culture. Five pigs in one group were inoculated with RV; a second and third group of 4 pigs each were inoculated with AHCV and FMDV, respectively; a fourth group of 8 vaccinated pigs was retained as controls. All the pigs were given virulent ASFV at the first signs of leukopenia and thermal reaction following AHCV, FMDV, and RV inoculations.

None of the pigs with leukopenia after challenge survived. Those pigs without leukopenia survived despite development of a febrile reaction. Seven of 13 vaccinated pigs failed to survive challenge inoculation after infection with stressor viruses. Six of the 7 pigs died with the acute form of the disease. Among controls vaccinated but not stressed, only 2 of 8 pigs died after challenge inoculation. None of the controls died with the acute form of the disease. In previous trials, using the same virus for immunization without added stressors, only 6 of 46 pigs died after challenge inoculation. These findings, although not conclusive, suggest that stressor viruses may have predisposed pigs to subsequent challenge inoculation with ASFV.

The presence of pathological alterations in lungs of 5 of 7 pigs, despite an acute course in all but one pig, further hints at the lung lesion phenomena associated with field vaccination as reported by Ribeiro and Botija.

The growth and some stability characteristics of African Swine Fever virus has been studied to aid in classifying ASFV and in standardizing laboratory tests. A survey of wild pigs near the Kitale ASF outbreak revealed that ASFV was present in wart hogs living on the farm. Mode of actual transmission could not be ascertained but the possibility of infection was there. Further studies on wart hogs from Kenya and Tanganyika have shown that many, if not all of these animals, have been previously infected and harbor ASFV in their tissues, especially the lymph nodes. Virus has not been demonstrated in the blood of any of those sacrificed as yet and in only a few has it been found in the spleen. Virulent virus inoculated into these animals apparently did not multiply.

The agar diffusion precipitation test has proved to be a very efficient practical tool for the detection of ASF antigen in tissues from pigs dying acutely of ASFV. A fluorescent antibody technique has been developed and some of its possibilities demonstrated.

An isolation of ASF virus was made from a giant forest hog and transmission of ASF between domestic pigs was shown possible by the tick Ornithodoros moubata.
(PIADL and Kenya) (ADP a9-2)

Under the terms of a PL 480 agreement, research is being conducted at the Servicio de Patologia, Patronata de Biologia Animal, Embajadores, Madrid, Spain, on rapid and accurate diagnostic methods for African Swine fever. USDA scientists, working on ASF in Africa, developed a laboratory test for the diagnosis of ASF. This is based on the adsorption of red cells onto cultures of buffy coat cells. Only those cells which are infected with ASF virus will adsorb red blood cells. The occurrence of ASF in Spain, and the need to conduct diagnosis on samples suspected of being ASF, provided an opportunity to study this method of diagnosis under actual conditions. The Spanish work has shown the test to be specific for ASF. They have published variously on their application of the hemadsorption test for diagnosis of ASF. For the most part, these publications have appeared in Spanish veterinary journals and in publication media of the Office of International Epizootics (OIE), Paris, France. (Spain) (E25-ADP-4)

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African Swine Fever

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PARASITES AND PARASITIC DISEASES OF SWINE
Animal Disease and Parasite Research Division, ARS

Problem. Parasitic diseases have been estimated to cost the swine industry of the United States at least \$200 million annually. These diseases for the most part are cosmopolitan. Subclinical infections are the most frequent type and the most costly, yet they are generally so difficult to recognize that they often are overlooked entirely. Diagnosis is difficult, and successful treatments for many of these parasitisms are not available. Moreover, management practices to avoid the spread of parasitisms and to control them are often ineffectual. The problem is to develop, through a planned, balanced program of basic and applied research, knowledge for preventing, controlling, or eradicating parasitic diseases so as to provide for healthy swine, insure adequate supplies of parasite-free pork for an expanding population, avoid or minimize economic losses caused by these diseases, and thereby contribute to a prosperous agriculture, a sound national economy, a high standard of living, and a healthy population.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving parasitologists, veterinarians, biochemists, microbiologists, and pathologists engaged in basic and applied research in this problem area. Research is being conducted on the following diseases at the designated locations.

The Federal scientific effort devoted to research in this area totals 5.2 professional man-years. This effort is divided among sub-headings as follows:

Bionomics and Pathogenicity of the Swine Whipworm 1.0 at the Beltsville Parasitological Laboratory.

Swine Kidney Worms 0.1 under a cooperative agreement with the North Carolina Agricultural Experiment Station at Raleigh.

Investigations of *Trichinella spiralis* 1.0 at the Beltsville Parasitological Laboratory.

Pathogenic Role of the Intestinal Roundworm 0.1 under a cooperative agreement with the Nebraska Agricultural Experiment Station at Lincoln.

Strongyloides ransomi Infections in Baby Pigs 1.0 at the Swine Parasite Laboratory, Tifton, Georgia

Biochemical and Other Aspects of the Host-Parasite Relationship in the Development and Severity of Helminthiasis in Swine 2.0 at the Beltsville Parasitological Laboratory.

PROGRAM OF STATE EXPERIMENT STATIONS

Several States have work in progress aimed at providing improved control of swine roundworms. Efforts are centered on immunization or treatment procedures that will prevent tissue damage caused by migration of ascarid larvae through vital organs. Soil sterilants are under evaluation to find a practical method for destroying infective ascarid eggs.

Treatments are being developed to control damage due to migration of the swine threadworm through body tissues. Cooperative studies are in progress with the Department to evaluate management practices as a means for controlling swine kidney worms.

6.4 professional man-years of scientific effort are involved in swine parasite research at the States.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Swine Whipworm (*Trichuris suis*)

At the Beltsville Parasitological Laboratory, research disclosed that the eggs of *Trichuris suis*, the swine whipworm, were infective to susceptible pigs after an exposure of 8 years and 11 months, to outdoor conditions on the surface of, and buried at depths of 4 and 8 inches, in sandy loam soil in the vicinity of Beltsville, Maryland. The constant presence of moisture in the soil of the experimental plots may have been partially responsible for their survival. During the period of observation the temperature at the surface of the soil ranged from 5°F in winter to 101°F in summer.

(BPL)

(ADP b2-10)

B. Swine Kidneyworm (*Stephanurus dentatus*)

Under a cooperative agreement research workers at the North Carolina Agricultural Experiment Station, Raleigh, report that three specific-pathogen-free (SPF) gilts were bred and isolated on pastures free of swine kidney worm contamination. Several days before anticipated farrowing, they were moved to cleaned isolation units and administered dichlorvos to remove any possible gastrointestinal parasites. Three consecutive fecal examinations proved negative. Offspring of these gilts were weaned at 5 weeks of age and remained in the isolation units. Pigs obtained from other sows and maintained on colostrum-free diets were placed in similar isolation units.

At 8 weeks of age a total of 18 pigs were infected with a single oral dose of infective larvae of *Stephanurus dentatus*. Dose levels were 10,000, 20,000, 30,000, 40,000, and 50,000 larvae per group. A comparable control group was maintained parasite-free.

Haematological and chemical studies conducted consisted of the following: 1) composite eosinophil count utilizing the modified Pilot technique; 2) sedimentation rate by the Winthrobe method; and 3) serum glutamic pyruvic

transaminase determined as described in Sigma Chemical Co. Tech. Bulletin No. 410.

Results of these studies were: 1) Eosinophil counts began to rise approximately one month post-infection and reached peak levels approximately 6 weeks post-infection. These peak levels remained thusly for nearly 2 months and then began a gradual decline. 2) Sedimentation rate was not affected. With data obtained in human medicine, following extensive liver pathology, sedimentation rates are known to increase. This was not found to be true in light of massive liver damage inflicted by kidney worm larvae. 3) Serum transaminase values proved inconclusive. Fluctuation in values were not correlated to pathological changes or stages of infection. This test system does not seem to predict evidence of liver pathology as one would expect.

Pigs from each dose level were necropsied and colored photographs were made to record liver damage. Relationship between level of infection and liver damage is being established. Tissues were taken for histological examination. No larvae were recovered from liver or other organs. It has been our experience that no larvae are recovered from animals with less than 4 months infection.

(North Carolina)

(ADP b2-11)

C. Trichinosis (Trichinella spiralis)

In research studies at the Beltsville Parasitological Laboratory, trichinae, passed in the feces of pigs during the 3-day period following the administration of an initial dose of the infective larvae of Trichinella spiralis, were found to be infective to three comparable non-trichinous pigs which were fed feces of the donor pigs during this period. Transmission also occurred during the 3-day period following the administration of the second dose of larvae to the donor pigs, 30 days after the initial infection. In this instance, all nine of the non-trichinous pigs became infected, including six that were penned separately from the donor pigs and were hand-fed feed mixed with feces from the donor pigs. This finding indicated that infective trichinae were probably present in greater numbers in the feces of pigs that had become resistant to infection with the parasite following a previous infection. Of significance was the finding that 2 of the 3 non-trichinous pigs penned with the donor pigs from the fourth to the twenty-ninth day after reinfection also became trichinous. In this instance transmission probably occurred through the ingestion of adult females containing infective embryos, which would undoubtedly be passed in larger numbers by resistant pigs than by susceptible swine.

The presence of 122 pounds of large cuts of pork (hams and shoulders) in a home freezer with a capacity of 300 pounds of meat, more than doubled the time required to destroy trichinae in small packets of pork chops frozen at the same time, when the freezer was adjusted to maintain a temperature of 0°F. This phenomenon did not occur when the pork chops were frozen with approximately the same total quantity of pork present in the freezer but made up of smaller cuts of pork.

Additional evidence was obtained to demonstrate that the resistance of trichinae in large cuts of pork to freezing at 0°F. was increased by a prior exposure to 35°F. (5.6°C) for a period of 150 days, and that some larvae so treated may survive at least 20 days in a 9 cubic foot freezer filled with 309 pounds of pork in large cuts. If such a freezer is overloaded by as much as 19 percent, trichinae in large cuts of fresh pork are killed in 20 days, but pork precooled for 179 days contained surviving larvae. If the freezer is overloaded by as much as 38 percent, trichinae may survive 20 days in fresh pork. In this instance, trichinae in precooled pork survived no more than 17 days at 0°F. (BPL) (ADP b2-15)

Investigations on trichinellosis are also being conducted under a PL 480 grant to the Polish Academy of Science, Warsaw, on the epidemiological, epizootiological, and immunological aspects of this disease to establish information on the incidence of Trichinella spiralis in people and domestic and wild animals throughout the country. Allergic tests for diagnosis of the disease are being assessed. Other studies indicate that the intestinal flora in the host's digestive tract may affect the invasive ability of the larvae. (Poland) (E21-ADP-9)

D. Intestinal Roundworm (Ascaris suum)

In work at the Nebraska Agricultural Experiment Station, Lincoln, under a cooperative agreement with the USDA, sows were orally immunized with repeated doses of infective eggs of Ascaris suum. Baby pigs from the immunized sows made highly significant average daily weight gains (ADG) when compared with baby pigs from nonimmunized sows.

Intraperitoneal injections of a lipid enzyme complex isolated from the intestinal tract of adult Ascaris suum elicited the development of protective immunity in mice against the migrating larvae of A. suum. This was manifested by a significant reduction in the number of larvae migrating to the lungs and a rise in the relative percent gamma globulin in the serum.

Leucine amino peptidase, isolated from the intestinal tract of adult A. suum, did not elicit an immunologic response in mice when the enzyme was placed in the drinking water. Apparently the addition of leucine amino peptidase to the drinking water resulted in the mice becoming more susceptible to parasitism as a significantly larger number of larvae were recovered from the liver and lungs of the mice in the enzyme group when mice were challenged with 20,000 infective eggs of A. suum.

Intraperitoneal injections of leucine amino peptidase, isolated from the intestinal tract of adult A. suum, elicited the development of protective immunity in pigs against the migrating larvae of A. suum. This was evidenced by a significant reduction in the number of larvae migrating to the lungs of immunized pigs and a significant elevation in serum gamma globulin.

Inorganic pyrophosphatase was isolated from second stage larvae of A. suum by ammonium sulfate fractionation and subsequent CM cellulose chromatography. The characteristics of the enzyme were determined.

Semipurified inorganic pyrophosphatase was isolated from second stage larvae of A. suum and compared with an enzyme obtained from adult A. suum. Tests indicated stereochemical continuity of pyrophosphatase during development of the parasite. The role of pyrophosphatase in the production of functional immunity was investigated by attempted hyperimmunization of rabbits with adjuvanted enzyme.

If the anthelmintic 2,2-dichlorovinyl dimethyl phosphate (DDVP) is present in the intestine of pigs when larvae of A. suum escape from the egg shell, the larvae will be killed. When administered orally, DDVP did not kill the tissue phase of the migrating larvae of A. suum.

(Lincoln, Nebraska)

(ADP b2-12)

E. Strongyloides ransomi Infections in Baby Pigs

At the Regional Research Laboratory, Tifton, Georgia, researchers found that experimental infection of weaned pigs can severely affect their rate of gain and may lead to death of some pigs. Infected pigs fed an inadequate ration containing 14% crude protein did not gain as well as pigs fed an adequate ration containing 16% crude protein in the fall of 1963. When the experiment was repeated in the spring of 1964, no significant difference was observed between pigs on the two rations. The combined results show that S. ransomi causes a lowered rate of gain in infected pigs regardless of the ration fed, although the deleterious effects may be more severe in pigs fed an inadequate ration.

Experimental infection of Duroc and Hampshire pigs with S. ransomi reduced their naturally acquired Ascaris suum infection. Duroc pigs raised with Hampshire pigs had 6 times as many ascarids. These unsuspected variables apparently masked possible differences in the reaction of the two breeds to infection with S. ransomi.

(Tifton, Georgia)

(ADP b2-17)

F. Biochemical Aspects of Host-Parasite Relationship

At the Beltsville Parasitological Laboratory researchers report that females of the swine kidney worm, Stephanurus dentatus, and large roundworm of poultry, Ascaridia galli, had a much higher total lipid content than the males of these parasites. The total lipid content of the female swine kidney worm was 43.8 mg/gram of worm tissue; of the male 27.7 mg. Female Ascaridia from poultry yielded 25 mg/gram of worm tissue, whereas the males had only 12.9 mg. Females also had a larger percentage of neutral lipids than the males; 54.4 percent versus 22.05 percent in the kidney worm and 59.7 percent versus 28.4 percent in the poultry ascarid. These differences could be accounted for in the greater amount of glycerides in the neutral lipid fraction of the female worms. Since glycerides are sources of energy

the presence of relatively large amounts of these compounds in the female may be related to the functions of egg production and oviposition.

(BPL)

(ADP b2-18)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Swine Kidneyworms

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